Request for Rulemaking and Letters of Authorization

Under Section 101(a)(5)(A) of the Marine Mammal Protection Act

for the Take of Marine Mammals Incidental to Fisheries Research Activities

conducted by the

Northwest Fisheries Science Center

within the

California Current, Puget Sound, and Lower Columbia River Ecosystems

August 2015

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1.0 A DETAILED DESCRIPTION OF THE SPECIFIC ACTIVITY OR CLASS OF ACTIVITIES THAT CAN BE EXPECTED TO RESULT IN INCIDENTAL TAKING OF MARINE MAMMALS

This application, submitted to the National Marine Fisheries Service (NMFS) Office of Protected Resources, requests rulemaking and subsequent letters of authorization under the Marine Mammal Protection Act (MMPA) of 1972 for the incidental take of marine mammals during fisheries surveys and related research activities conducted by the Northwest Fisheries Science Center (NWFSC), National Marine Fisheries Service (NMFS), NOAA. Management of certain marine mammals falls under the jurisdiction of the NMFS under the MMPA and Endangered Species Act (ESA). Mechanisms exist under both the ESA and MMPA to assess the effect of incidental takings and to authorize appropriate levels of take.

The Federal government has a trust responsibility to protect living marine resources in waters of the United States (U.S.), also referred to as federal waters. These waters generally lie 3-to-200 nautical miles from the shoreline [those waters 3-12 nautical miles offshore comprise territorial waters and those 12-to-200 nautical miles offshore and comprise the Exclusive Economic Zone (EEZ)]. The U.S. government has also entered into a number of international agreements and treaties related to the management of living marine resources in international waters outside of the U.S. EEZ (i.e., the high seas). To carry out its responsibilities over federal and international waters, Congress has enacted several statutes authorizing certain federal agencies to administer programs to manage and protect living marine resources. Among these federal agencies, NOAA has the primary responsibility for protecting marine finfish and shellfish species and their habitats. Within NOAA, the NMFS has been delegated primary responsibility for the science-based management, conservation, and protection of living marine resources.

Within the area covered by this MMPA application to incidentally take marine mammals, NMFS manages finfish and shellfish harvest under the provisions of several major statutes, including the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the MMPA, and ESA. Accomplishing the requirements of these statutes requires the close interaction of numerous entities in a sometimes complex fishery management process. In the Northwest, the entities involved are a NMFS Regional Fisheries Science Center, NMFS Regional Office, NMFS Headquarters, one Fisheries Management Council, and five Fisheries Commissions, each described briefly below.

1.1 Fisheries Science Centers

In order to direct and coordinate the collection of scientific information needed to make informed decisions, Congress established six Regional Fisheries Science Centers based primarily on geographical boundaries (Figure 1-1). Each Fisheries Science Center is a distinct entity and is the scientific focal point for that region. Until recently, the Northwest Fisheries Science Center (NWFSC) provided scientific support for NMFS Northwest Region while the Southwest Fisheries Science Center (SWFSC) provided scientific support for NMFS Southwest Region. In the fall of 2013, NMFS merged the Northwest and Southwest regional offices into a single administrative unit, the West Coast Regional Office. However, the NWFSC and SWFSC remain separate research institutions which independently contribute scientific information to the West Coast Region, although they frequently collaborate and have overlapping geographical research areas.

The NWFSC plans, develops, and manages research programs that are grouped into four guiding themes. These themes encompass much of the work being done at NWFSC. The themes are useful tools for research planning, and are linked to personnel, budget, project, data, and publication information through the NWFSC Project Tracking Database. The four guiding themes are as follows:

- Ecosystem approach to management for the California Current Large Marine Ecosystem

- Habitats to support sustainable fisheries and recovered populations
- Recovery, rebuilding, and sustainability of marine and anadromous species
- Oceans and human health

The NWFSC is based out of the Montlake Laboratory and Headquarters in Seattle, Washington and also includes five research stations: Mukilteo, Manchester, Point Adams, Pasco, and Newport (Figure 1-2). Since 1983, the NWFSC has conducted fisheries research surveys off the Pacific coast of the United States (U.S.), primarily within 200 miles of the shoreline from as far north as the Dixon Entrance, Canada, the Puget Sound, Washington, across the Strait of Juan de Fuca and as far south as the U.S. - Mexico border. The NWFSC conducts fisheries research in three distinct marine areas: the California Current Research Area (CCRA) (Figure 1-2), the Puget Sound Research Area (PSRA) (Figure 1-3), and the Lower Columbia River Research Area (LCRRA) up to the Bonneville Dam (Figure 1-4). More details about the extent of the areas surveyed are provided in section 2. These surveys are conducted to monitor important indicators of the overall health and status of the Region's fisheries resources and the ecosystems that support these resources.

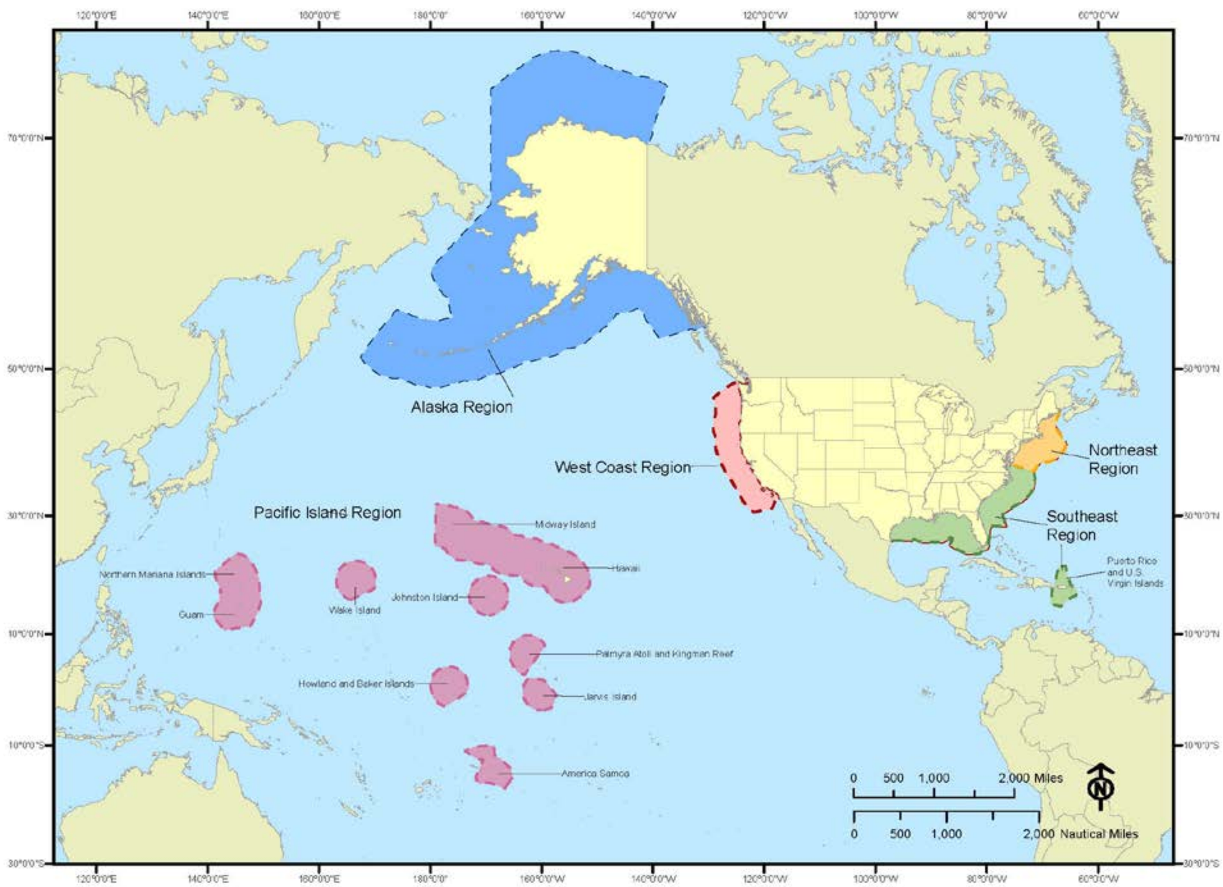

Figure 1-1 NMFS Fisheries Science Center Regions

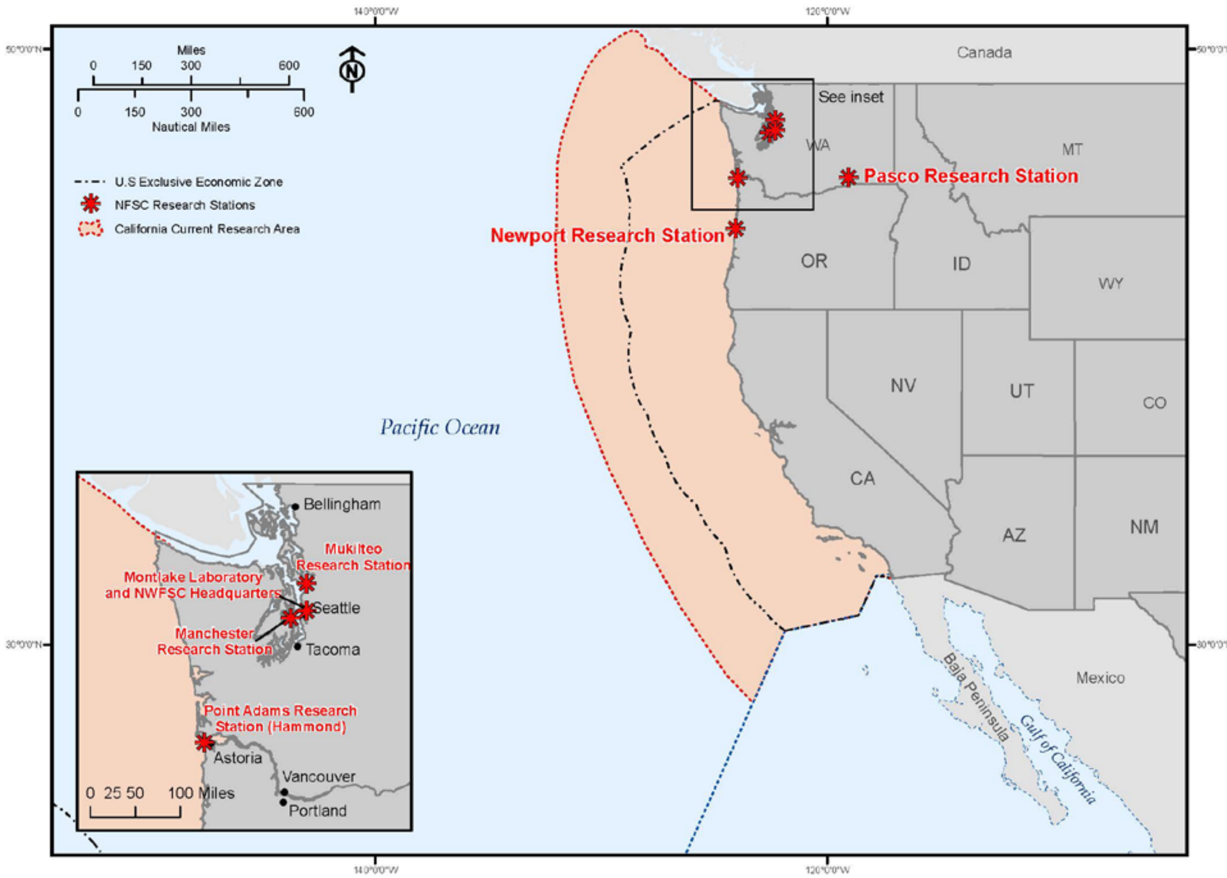

Figure 1-2 Map Showing the California Current Research Area

Locations of the Montlake Laboratory and NWFSC headquarters in Seattle as well as the five NWFSC research stations at Mukilteo, Manchester, Pasco, Point Adams, and Newport are shown.

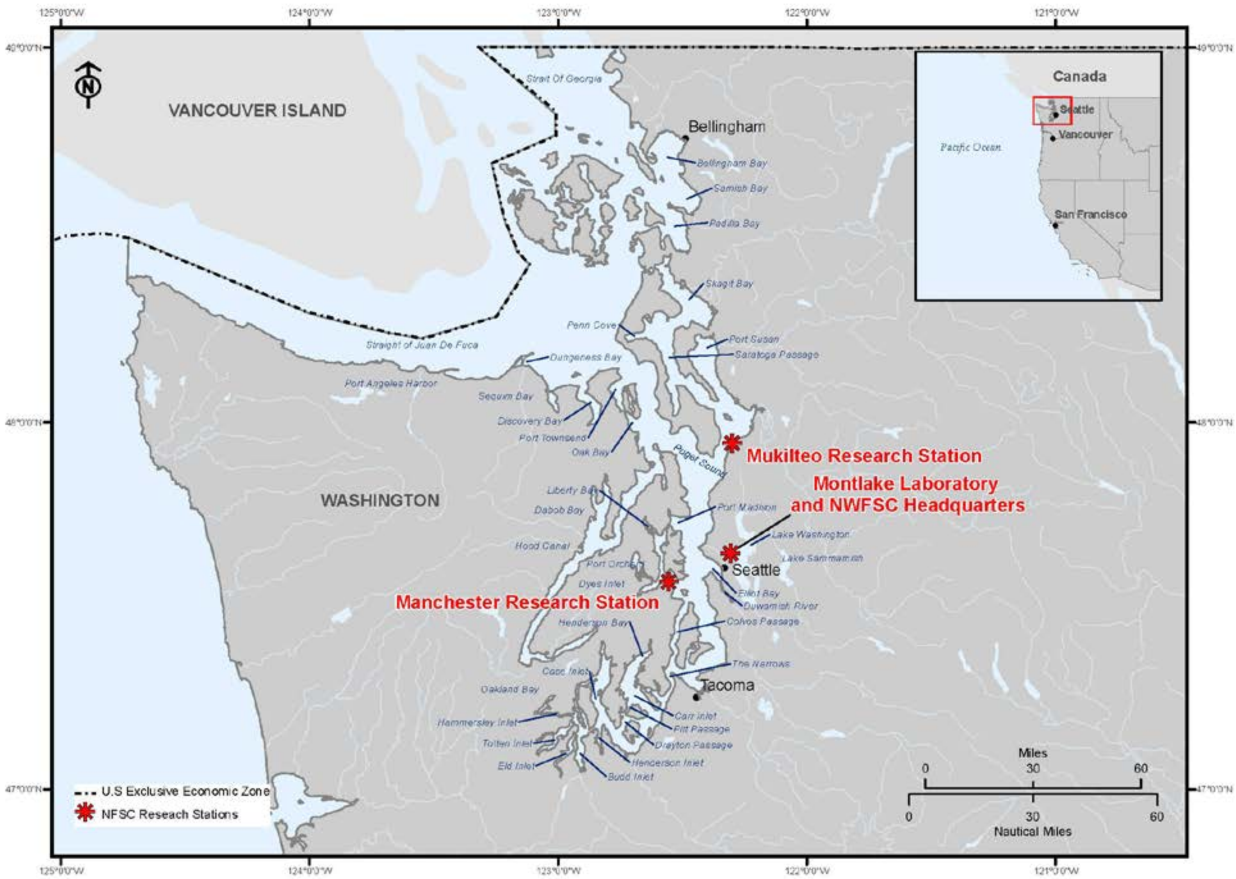

Figure 1-3 Map Showing the Puget Sound Research Area

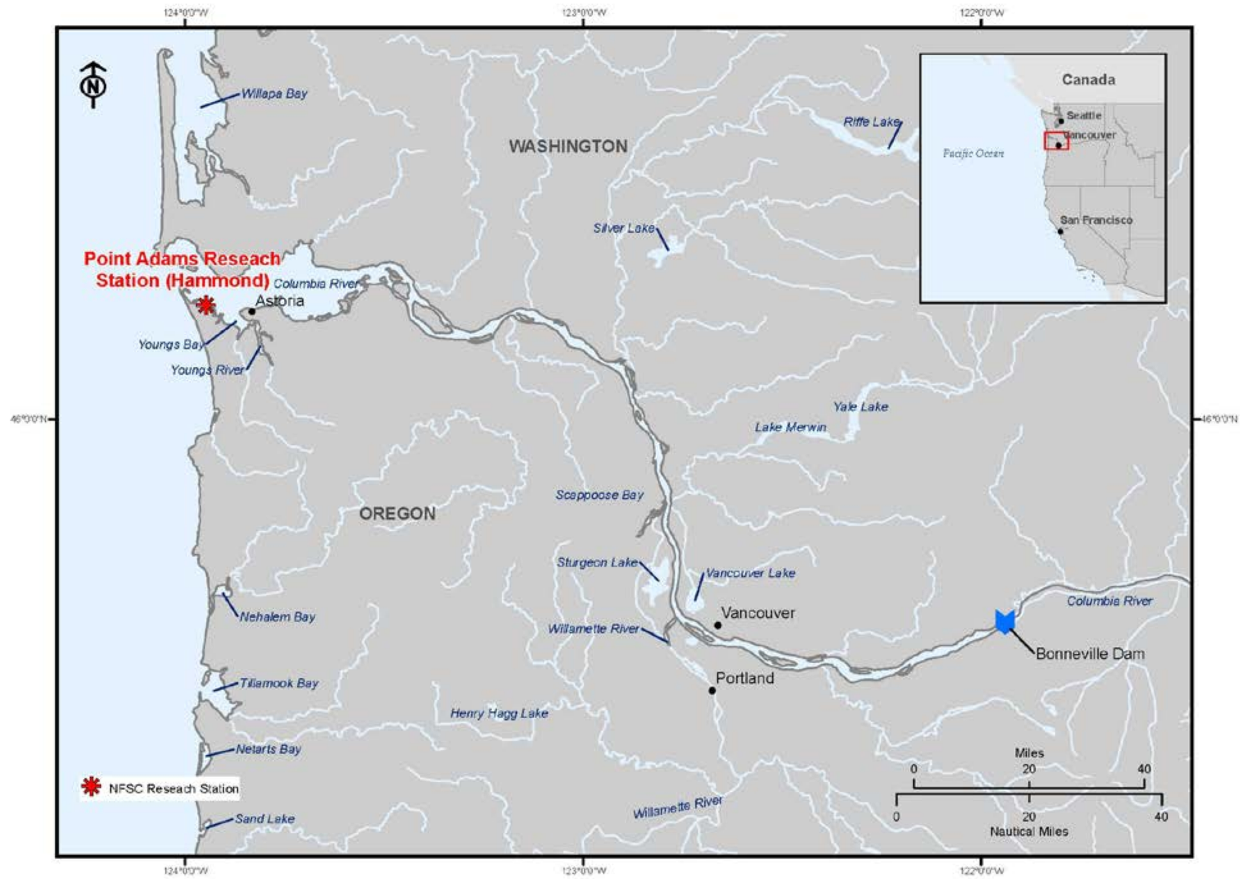

Figure 1-4 Map Showing the Lower Columbia River Research Area

1.2 Fisheries Management Councils

In order to encourage a collaborative approach to fisheries management, the MSA established the nation's eight Regional Fishery Management Councils. On the West Coast, the Pacific Fishery Management Council (PFMC) includes Washington, Oregon, California, and Idaho. The North Pacific Fishery Management Council (NPFMC) is concerned with the waters around Alaska. And in the far west, the Western Pacific Regional Fishery Management Council (WPRFMC) covers federal waters off the shores of the U.S. Pacific Islands including Hawaii, American Samoa, the Mariana Archipelago, and U.S. Pacific Remote Islands. The councils, which include fishing industry representatives, fishers, scientists, government agency representatives, federal appointees, and others, are designed to provide all resource users and managers a voice in the fisheries management process. Under the MSA, the Councils are charged with developing Fishery Management Plans (FMPs) and management measures for the fisheries occurring within the EEZ adjacent to their constituent states. Data collected by Fisheries Science Centers are often used to inform FMPs, as well as to inform other policies and decisions promulgated by the Fishery Management Councils. Such policies and decisions sometimes affect areas that span the jurisdictions of several Fishery Management Councils, and make use of data provided by multiple Fisheries Science Centers.

1.3 Marine Fisheries Commissions

In addition to providing information to domestic fisheries management councils, the NWFSC provides scientific advice to support several domestic and international fisheries commissions, including the Pacific States Marine Fisheries Commission (PSMFC), the International Pacific Halibut Commission (IPHC), the Pacific Salmon Commission (PSC), the Pacific Whiting Joint Management Committee (PWJMC), and the North Pacific Anadromous Fish Commission (NPAFC). Marine Fisheries Commissions were created in the recognition that fish do not adhere to political boundaries. In the Northwest, the Pacific States Marine Fisheries Commission (PSMFC) is a domestic organization that promotes and supports policies and actions to conserve, develop, and manage fishery resources in California, Oregon, Washington, Idaho and Alaska. Although the PSMFC has no regulatory or management authority, the commission serves a number of other functions vital to the sustainable utilization of marine fisheries, such as providing for collective participation for Pacific States to work on mutual concerns, and serving as a forum for discussion of fisheries resource issues that may fall outside of state or regional management council jurisdiction.

The IPHC is an international organization responsible for the preservation of the halibut fishery of the North Pacific Ocean and Bering Sea. The main functions of the IPHC are to conduct and coordinate scientific studies relating to the halibut fishery and to formulate regulations designed to develop the stocks of halibut to levels that permit optimal utilization. The IPHC submits regulations, mainly the total allowable catch of halibut, to the governments of the United States and Canada for approval. Upon approval, the regulations are enforced by the appropriate agencies of both governments. The NWFSC provides information to the IPHC to assist with the development of effective regulations.

The PSC is a sixteen-person body with four Commissioners and four alternates each from the United States and Canada, representing the interests of commercial and recreational fisheries as well as federal, state and tribal governments. Similar to the IPHC, the Pacific Salmon Commission provides regulatory advice and recommendations to the appropriate agencies in the United States and Canada. The commission has responsibility for all salmon originating in the waters of one country, which are subject to interception by the other, affect management of the other country's salmon, or affect the biology of salmon stocks of the other country. In addition, the Pacific Salmon Commission is charged with taking into account the conservation of steelhead trout while fulfilling its other functions. The NWFSC provides scientific and technical information to the Pacific Salmon Commission.

The PWJMC was established under the 2003 Agreement between the Government of the United States of America and the Government of Canada on Pacific Hake/Whiting. The committee, which includes eight members (four appointed by each party), reviews advice from the Joint Technical Committee, Scientific Review Group and Advisory Panel and then recommends the total allowable catch each year. The committee also provides direction to, and refers technical issues to, the Joint Technical Committee and Scientific Review Group. The NWFSC provides scientific and technical information to the PWJMC, including contributions to stock assessments.

The NPAFC was established under the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean, signed in February 1992. The contracting parties include Canada, Japan, Republic of Korea, the Russian federation, and the United States. The primary objective is to promote the conservation of anadromous stocks in the Convention area. The NWFSC provides scientific and technical information to the Commission.

1.4 Role of Fisheries Research in Federal Fisheries Management

Fisheries managers use a variety of techniques to manage trust resources, a principal one being the development of FMPs. FMPs are used to articulate fishery goals as well as the methods used to achieve those goals, and their development is specifically mandated under the MSA. The NWFSC provides scientific information and advice to assist with the development of FMPs prepared by the PFMC and other agencies.

Through its Regional Fisheries Science Centers, NMFS conducts both *fisheries-dependent* and fisheries-*independent research* on the status of living marine resources and associated habitats. In some areas of the U.S., fisheries-dependent research includes research conducted on-board commercial or recreational fishing vessels during their fishing operations. However, in the Northwest Region, NWFSC fisheries-dependent research is limited to collection of harvest data while fishing vessels are in port and does not involve research conducted in marine waters during fishing operations. The Center has an observer program and an electronic log book program associated with fishing operations but do not involve any marine mammal issues. NWFSC fisheries-dependent research is therefore not discussed further in this application. Fisheries-independent research is designed and conducted independent of commercial or recreational fishing activity to meet specific research goals.

1.5 Northwest Fisheries Science Center Research Divisions

Each of the Center's divisions provides science support for moving resource management toward a more holistic, ecosystem-based strategy. The NWFSC's ecosystem approach promotes a shift away from current management that often focuses in the short-term on a single species. The approach focuses on interactions within and among ecosystems, offers long-term perspectives, and fully integrates analyses across a range of scientific disciplines. Center research activities are conducted in three geographic areas that correspond to: 1) the California Current area of the Pacific Ocean; 2) Puget Sound and associated estuaries; and 3) the lower Columbia River below the Bonneville Dam (see Section 2.0 below).

1.5.1 Conservation Biology Division

The Conservation Biology Division focuses on the preservation of biological diversity found in living marine resources. Many of the challenges society faces regarding biodiversity and the protection of endangered species require the development of novel approaches for determining how human and natural factors influence the viability of marine species. To meet these challenges, the Division has assembled a group of biologists from a broad spectrum of scientific disciplines, including risk analysis, genetics, evolutionary biology, ecology, and population biology. As a group, the Conservation Biology Division is dedicated to conducting research necessary to help address critical conservation needs, with the primary focus on the recovery of ESA-listed Pacific salmon populations and depleted stocks of other marine species, including southern resident killer whales, eulchon, and several species of ESA-listed rockfish in Puget Sound.

1.5.2 Environmental and Fisheries Sciences Division

The Environmental and Fisheries Sciences Division conducts research to assess and reduce natural and human-caused impacts on environmental and human health, and to improve methods for fisheries restoration and production in conservation hatcheries and in aquaculture. Environmental health and conservation research examines environmental conditions and the impacts of chemical contaminants, marine biotoxins, and pathogens on fishery resources, protected species, habitat quality, seafood safety, and human health. Fisheries restoration and aquaculture includes research on the challenges associated with captive rearing, nutrition, reproduction, behavior, disease control, engineering, hatchery technology and larval/juvenile quality for protected, depleted and commercially valuable species.

1.5.3 Fish Ecology Division

The Fish Ecology Division focuses on understanding the complex ecological linkages between commercially and recreationally important marine and anadromous fishery resources of the Pacific Northwest and their habitats. Particular emphasis is placed on investigation of the biotic and abiotic factors that control growth, distribution, and survival of important species and on the processes driving short-term and long-term population fluctuations. The Fish Ecology Division researches the migrational behavior and ecological processes that affect distribution, abundance, growth, and survival of anadromous and marine fishes in Pacific NorthWest Coastal estuaries and marine waters.

1.5.4 Fishery Resource Analysis and Monitoring Division

The mission of the Fishery Resource Analysis and Monitoring (FRAM) Division is to provide the scientific basis for the management of West Coast Groundfish stocks and their ecosystems. This involves comprehensive analysis of data from fishery monitoring, fishery-independent resource surveys, and biological investigations. The results provide estimates of the current status and future trends in abundance and productivity of marine fishery resources, evaluations of the potential effects of fishery management alternatives on abundance and yield of living marine resources, and better information on fishery bycatch and other multi-species issues.

The West Coast groundfish fishery includes about 90 commercially fished stocks off Washington, Oregon and California. Analysis of stock assessment is critical to achieving sustainability in the West Coast groundfish fishery. Historically, shortcomings in the data (e.g., only landed catch monitored, only triennial surveys that do not cover all species, etc.) have resulted in uncertainty and associated controversy in assessments. To diminish the uncertainty associated with stock assessments, the FRAM division conducts annual groundfish surveys from the Canadian border to the Mexican border along the West Coast of the U.S. using chartered local commercial fishing vessels. These surveys are conducted with trawls outfitted with a suite of acoustic sensors to monitor trawl performance. The surveys provide robust information about distribution, relative abundance, and age structure of important groundfish populations to inform stock assessment models.

Since 2003 FRAM’s Acoustics Team has been conducting the joint U.S.–Canada integrated acoustic and trawl surveys of Pacific hake (Merluccius productus) off the West Coast of North America (conducted in conjunction with the Southwest Fisheries Science Center as part of the Joint Pacific Hake and Sardine Integrated Acoustic Trawl Survey). Acoustics data are used to inform hake biomass estimates, which are then verified by trawl catches. These time-series surveys are the primary data source for the U.S.-Canada Pacific hake stock assessment, which uses age-structured assessment models to estimate current and future hake abundance. The assessments provide information to assist fishery managers in planning future harvests.

1.6 NWFSC Fisheries Research Activities

The following is a summary of activities conducted by the NWFSC with potential to take marine mammals incidental to fisheries research activities. The NWFSC is requesting rule making and subsequent Letters of Authorization for the proposed activities. The descriptions below include the location, time of year the surveys occur and gear used. Additional information and detail for each survey is in Table 1-1 and Appendix A. In general, all NWFSC surveys are set in an ecological context. That is, the Center conducts concurrent hydrographic, oceanographic, and meteorological sampling in addition to marine resource surveys. All vessels used for research (except some small boats) may use commercial acoustic equipment for navigation purposes but only certain surveys use active acoustic equipment as part of their sampling protocols and those surveys are identified below.

1.6.1 Surveys Conducted in the California Current Research Area (CCRA)

Studies Using Trawl Gear

The following are brief summaries of the research programs and types of gear used by the NWFSC and considered in this LOA application:

Bycatch Reduction Research: This survey occurs from April to October in waters from southern Oregon to Canada. It is a research effort to test gear improvements to reduce bycatch of non-target fish species. Current examples include testing low-rise bottom trawls, flexible sorting grates in bottom and midwater trawls, and open escape window bycatch reduction devices in midwater trawls. The survey is conducted on chartered commercial fishing vessels and requires 30-90 days at sea (DAS). Research is conducted in daytime only.

The protocols for this survey include deployment of commercial bottom trawls of various net sizes towed at 1.5-3.5 knots (kts) for up to 4 hours at depths of 50-1000 meters (m). There are approximately 40 trawls per year with this type of gear. Protocols also include deployment of a double rigged shrimp trawl with various net sizes towed at 1.5-3.5 kts for 30-80 minutes at depths of 100-300 m. Up to 60 double-rigged shrimp shrimp trawls occur each year. Commercial pelagic midwater trawls would also be deployed with various net sizes towed at 1.5-3.5 kts for an average of two hours but may be towed up to 8 hours at depths of 50-1000m. There are up to 60 midwater trawls per year.

The type of trawl used and the duration that it is fished depends on the fishery (i.e., target species), bycatch species of concern, changing fishing regulations (e.g., annual catch limits, catch shares, bycatch species prohibitions, ESA listings), vessel, and bycatch reduction engineering methods being evaluated. All these can factor into the trawl gear being fished (studied) and the duration of the haul.

Additional protocols include the use of various models of echosounders and sonars (38-200 kHz, ≤224 dB/1µPa).

*Camera Trawl Research***:** This survey is conducted between March and September along the U.S. west coast from southern California to Southeast Alaska, including Canada. These are research/development and pilot surveys to refine the development of optical-trawl samplers as applied to acoustical and other surveys, including testing of hardware and software, to assess abundance and species composition in trawls used to sample commercially important groundfish. The survey is conducted on the NOAA Ship R/V *Bell M. Shimada* and charter vessels for 30-70 DAS. Research is conducted in daytime only.

The protocols for this survey include deployment of a midwater Aleutian wing trawl (AWT) with a headrope of 334 feet (ft) (101.8 m) towed at 2.8–3.5 kts at depths down to 500 m. The duration of the tows varies depending on the time it takes to verify the composition of the schools of fish producing acoustic signals. Approximately 75 trawls/year will be deployed (in addition to trawls conducted as part of hake survey)

Flatfish Brood Stock Collection: This survey occurs intermittently up to 20 times annually in Puget Sound and the Washington coast. This survey collects fish for broodstock for aquaculture development. A charter fishing vessel and NOAA small boats are used and require around 40 DAS. Gear used includes commercial bottom trawl (6-24 trawls/year) with various net sizes towed at <3.5 kts for 10 min at depths >10 m and hook-and-line (18 collection trips/year with up to 12 lines in the water at once). Daytime operations only.

Groundfish Bottom Trawl Survey: This survey occurs annually between May and October from the US/Mexico to the US/Canada borders. This is a fisheries independent survey to monitor groundfish distribution and biomass along the US west coast at depths of 55 to 1280 m. The survey is conducted from two chartered commercial fishing vessels operating at the same time to cover the necessary stations. There are two sampling periods, May to July and August to October, and requires about 190 DAS total for all vessels. Sampling occurs only during the daytime.

The protocols for this survey include deployment of a modified Aberdeen bottom trawl (and video camera) with a 5 x 15-m opening towed at 2.2 kts for approximately 15 min at depths of 55-1280 m. There are approximately 737-773 trawls per year. Additional protocols include the use of a CTD profiler and various models of echosounders and sonars (27-200 kHz; ≤ 224 dB/1µPa).

Hake Acoustic Survey: This survey is conducted each June-September on the US continental shelf from southern California to Southeast Alaska, including Canada. The purpose of the survey is to measure the abundance of hake. A NOAA vessel (R/V *Miller Freeman* or R/V *Bell M. Shimada*) is used for this survey that requires about 60-80 DAS. Sampling occurs only during the daytime. Echosounder acoustic gear is used to locate and assess the size of hake schools and midwater trawls are used to confirm identification of fish targets.

The protocols for this survey include deployment of a midwater AWT with a headrope of 334 ft (101.8 m) towed at 2.8-3.5 kts at variable depths. There are about 150 trawls/year; about five percent of which are Poly Nor'easter Bottom Trawl (PNE) bottom trawls with 89 ft headrope and 120 ft footrope towed at 2.8-3.5 kts for variable lengths of time to sample the fish producing the acoustic signal. Additional protocols include the use of various models of echosounders and sonars (1.5-200 kHz; ≤ 224 dB/1μPa).

Juvenile Salmon Pacific Northwest (PNW) Coastal Survey: This survey is conducted annually in continental shelf waters during May, June, and September from Newport, OR to Cape Flattery, WA. The survey assesses ocean condition, and growth and relative abundance of juvenile salmon and their survival during their first summer at sea. A charter commercial fishing vessel is used, or a NOAA research vessel if available. The duration is 36 DAS (roughly divided equally between May, June, and September). Sampling occurs only during the daytime.

The protocols for this survey include deployment of a Nordic 264 surface trawl (with a marine mammal excluder device) with a net size of 30 x 20 m and towed at approximately 3-4 kts for 30 min at depths down to 30 m. A CTD profiler and Niskin bottle, bongo net, vertical plankton net, and water pump are also used. There are about 180 trawls/year.

Marine Fish Broodstock Collection, Sampling, and Tagging: This survey is conducted annually at variable frequencies on the Washington coast. The purpose of the survey is to collect fish for broodstock for aquaculture development. Chartered fishing vessels are used and the survey duration is 10 DAS. Daytime operations only.

The protocols for this research include deployment of commercial bottom trawls with various net sizes towed at 1.5-3.5 kts for up to 4 hours at depths of 50-1000 m. The survey deploys approximately 10 trawls/year. Protocols also include deployment of a pelagic longline with a 3 hour soak time. Length of the mainline is 750-1000 fathoms with 500 circle hooks per set baited with squid. Approximately 30 sets occur each year. Additional protocols include the use of hook and line gear deployed by rod and reel. Eight anglers with eight lines in the water at a time fish for approximately 6 hours per day for a toal of 90 hours per year.

Northern Juvenile Rockfish Survey: This survey is conducted annually in May and June from Cape Mendocino, CA to Cape Flattery, WA. The survey measures the spatial abundance of juvenile fishes (focusing on rockfish species) in coastal marine waters of the northern California Current ecosystem as an index of recruitment potential. A charter commercial fishing vessel or NOAA vessel are used. The survey duration is 15-30 DAS and all tows are conducted at night.

The survey is conducted using a commercial modified Cobb trawl with a headrope of 26 m and an opening of 12 m height x 12 m width (144 m^2), with a 9.5 mm codend. The top of the headrope is fished at about 30 m depth and is towed at 2.7 knots for 15 minutes. The survey deploys about 100 trawls per year. Additional protocols can include the use of a CTD profiler, Bongo and Tucker plankton nets, and Simrad EK60 Multi-frequency echosounder (38, 70, 120, and 200 kHz; 228 dB/1μPa).

Studies Using Other Gears

Coastwide Groundfish Hook and Line Survey in Untrawlable Habitat: This study is conducted annually in May through October from the US/Mexico border to the US/Canada border. This is an expansion of research previously conducted only along the Southern California coast. The purpose is to assess abundance of structure-associated rockfishes in untrawlable areas of along the US West Coast. Survey sites will be the same every year unless a site is unavailable due to weather or sea condition. The survey will be conducted using three or four chartered sportfishing vessels, with 250 DAS annually. Fishing occurs in daytime only. The gear used is hook-and-line deployed from rod and reels fished at 15-250 m depth for 5 minutes per set, camera sled, CTD profiler, and Furuno echosounder (50 and 200 kHz; 212 dB/1µPa). There will be 1000 sites with up to 75,000 hooks total per year (6,250 hook-hours/year).

Near Coastal Ocean Purse Seining: This study is conducted monthly between May and September nearshore near the mouth of the Columbia River, OR. The purpose is to study salmon habitat use in nearshore areas of the ocean near the Columbia River. A chartered commercial fishing vessel is used with purse seines that measure 750 ft x 60 ft or 1000 ft x 40 ft with mesh size: 0.625" (net body); 1.3" (tow end); 0.45" (bunt). Set duration is generally less than 1 hour, with about 75 sets/year completed in 12 DAS. Sets are made in daytime only.

Newport Line Plankton Survey: This survey occurs biweekly along the Newport Hydrographic Line (NH-Line) a long-term oceanographic sampling line located just north of Newport, Oregon. Sampling is conducted to assess oceanographic conditions and zooplankton, ichthyoplankton and krill species composition and abundance. The survey is conducted on the R/V *Elakha* chartered from Oregon State University and requires 26 DAS. Gear types include Bongo nets, vertical plankton nets, CTD profiler and Niskin bottle, and multi-frequency active acoustics (38, 70, 120, and 200 kHz). About 150 samples are collected per year; sampling occurs during both day and night.

Northern California Current Ecosystem Survey: This survey occurs approximately every other year as ship time is available so the season is variable. It occurs off the coasts of Washington and Oregon out to 200 nm. NOAA vessels R/V *Bell M. Shimada* and R/V *Miller Freeman* are used for an average of 12 DAS when the survey is conducted. Sampling is conducted to assess oceanographic conditions and plankton composition and abundance. Gear types include Bongo nets, vertical plankton nets, and CTD profiler and rosette water sampler. Sampling effort depends on ship time available and occurs on a 24-hour basis.

PNW Harmful Algal Bloom Survey: This survey is conducted annually during the summer and fall along the Oregon and Washington coasts. The purpose is to measure oceanographic conditions and phytoplankton species composition and abundance with an emphasis on harmful algal species. Samples are collected for: marine toxins, chlorophyll a, micro and macro nutrients, phytoplankton species ID and enumeration, DNA analysis, and dissolved oxygen. Vessels range from ocean-going research ships to small open skiffs, and the duration is a minimum of 10 DAS (ocean sampling 2 weeks to 3 months depending on available ship time). Sampling conducted on 24-hour basis. Gear used consists of plankton nets, CTD profiler, and rosette water sampler. About 200 samples are taken/cruise.

Technology Development Research: This research is conducted during the summer and fall from Washington to California. The objective of this study is to develop alternative sampling methodologies using autonomous underwater vehicles to assess groundfish abundance and distribution using video capturing equipment. The surveys are conducted using chartered vessels, UNOLs vessels, and NOAA vessels and take up to 20 DAS. Dives are made during the daytime only. Autonomous Underwater Vehicles, one of which is called Lucille, are used for several purposes. It is not tethered and is piloted remotely. It is several meters long. Dives have been up to 2000 ft deep. No sampling occurs other than video. Up to 17 dives are made per cruise.

Video Beam Trawl Collaborative Research: This survey is conducted annually along the continental shelf from Washington to Oregon during variable months. The purpose is to assess the seasonal and interannual distribution of young-of-the-year groundfishes and the potential impacts of hypoxia. A chartered commercial fishing vessel or a university research vessel is used and the duration is about 20 DAS. A two-meter-wide video beam trawl system is towed along the bottom at speeds of about 1.0-1.5 knots for 10 minutes during daylight hours, with about 20-40 deployments/year.

1.6.2 Surveys Conducted in the Puget Sound Research Area (PSRA)

Studies Using Trawl Gear

Beam Trawl Survey to Evaluate Effects of Hypoxia: This survey occurs during the summer and fall at five sites in southern Hood Canal and five sites in northern Hood Canal. The purpose is to examine the effects of hypoxia on demersal fishes in Hood Canal. A camera is mounted onto a beam trawl and video is reviewed to measure escape response time to the bottom trawl by various bottomfish. The survey is conducted on the R/V *Harold Streeter* and requires about 20 DAS. Daytime operations only. Gear consists of a 2-m wide beam trawl with a video camera and either an open or closed cod-end that is towed at various depths (30, 60, and 90 m) for approximately 10 minutes at about 2 kts. One tow per site per season, 20 tows total.

Marine Fish Collections Including Flatfish: This survey is conducted monthly in Puget Sound. The purpose is to collect of marine fishes for research including broodstock. Chartered vessels are used and the duration is about 15 DAS. Daytime operations only. Gear consists of variable commercial-sized bottom trawls with various net sizes towed at 1.5-3.5 kts for up to 4 hours at depths of 50-1000 m. About 40 bottom trawls/year are deployed.

Movement Studies of Puget Sound Species: These studies are conducted year-round in Puget Sound. The purpose is to study the movement of the following species: six gill shark, Chinook and coho salmon, lingcod, ratfish, steelhead, canary and Yelloweye rockfish, English sole, spiny dogfish, sunflower stars, and jellyfish. Vessels used include a variety of small boats such as whalers, as well as charter boats and effort requires about 25 DAS. Daytime operations only. Gear includes commercial bottom trawls with various net sizes towed at <3.5 kts for 10 min at dephs > 10 m. The survey deploys approximately 12 trawls per year. Protocols also include deployment of herring purse seines with a net size of 1500 x 90 ft and varable mesh sizes. The purse seines are set for <1 hour at depths < 50 m and a total of 12 sets per year. Protocols also include deployment of a demersal longline in about 200 feet of water with a mainline length of 600 ft and 30 circle hooks per set. Soak time is 90-120 minutes. There are approximately 3 sets per year for a total of 90 hooks. Additional protocols include the use of SCUBA divers (one collection trip per site), and VR2 passive acoustic receivers (continuous for season).

Puget Sound Marine Pelagic Food Web: This survey occurs in Puget Sound between April and October about every 5 years as funding is available. The purpose is to study the marine pelagic food web in Puget Sound focusing on the effects of land use and development of the food web. A chartered vessel is used and the duration is about 30 DAS. Daytime operations only. The gear consists of a Kodiak surface trawl with net size of 3.1 x 6.1 m towed at 1.8-2.2 kts for 10 min at depths <10 m. There are about 500 trawls/year when the study is conducted.

Skagit Bay Juvenile Salmon Survey: This survey is conducted in Puget Sound between April and September. The purpose is to assess coastal ocean conditions and measure the growth, relative abundance, and survival of juvenile salmon during their first summer at sea. A chartered vessel is used, and the duration is about 30 DAS. Daytime operations only. Gear consists of a Kokiak surface trawl with identical gear details and protocols as the Puget Sound Marine Pelagic Food Web Survey. There are about 180 trawls/year.

Studies Using Other Gears

Elwha Dam Removal: This survey occurs monthly in the Strait of Juan de Fuca. The purpose is to examine the potential effects of dam removal on nearshore fish including ESA-listed species. The vessel used is a 17-foot whaler. Operations are daytime only and require about 20 DAS. A 140-ft x 6-ft beach seine with <0.25-inch mesh is deployed for less than 10 minutes, with up to 140 samples per year.

ESA-listed Rockfish Genetics: This survey is conducted during April-November in Puget Sound, the San Juan Islands, and the Strait of Juan de Fuca. The purpose of the survey is to collect size, weight, location, depth, and genetic information from bottomfish species. The survey collects fin clips from all bottomfish captured with a focus on locating and getting genetic samples from ESA-listed rockfish species (yelloweye, canary, and Bocaccio rockfish). The intent is to release all fish unharmed. Various charter boats (F/Vs *Joker, Venture, Dash One, All Star, Morning Star, Fishfull Thinking II, Malia Kai, Cabazon, Darla Orion, Ann Patrice*) are used for the survey which is conducted for about 35-41 fishing days/year. Daytime operations only. Gear consists of hook-and-line fishing gear baited with herring and squid, or bottom jigs such as darts. Fishing effort averages 18.2 hook-hours per day and 750 hook-hours per year.

Herring Egg Mortality Survey: This survey is conducted between February and May in herring spawning locations in Puget Sound in water less than 10m (e.g. Squaxin Pass, Quartermaster Harbor, Elliot Bay, Port Orchard, Quilcene Bay, Holmes Harbor, and Cherry Point). This survey explores spatial variation and drivers of herring egg loss in Puget Sound. It also investigates if herring egg loss relates to vegetation types used by herring for spawning substrate, the presence of suspected large herring egg predators (diving ducks and large fish), and metrics of shoreline development. The R/V *Minnow* and R/V *Noctiluca* are used for this survey, which requires 20 DAS. Daytime operations only. SCUBA divers and predator exclusion cages are used to collect eggs. The cages are modified sablefish pots with 3 x 3-cm mesh openings, and are deployed for approximately 10 days. Five cages are deployed at each of five sites. Approximately 600 small vegetation samples with herring eggs are taken from each site per year.

Heterosigma akashiwo Bloom Dynamics and Toxic Effects: This study occurs in Puget Sound, Georgia Strait, and Strait of Juan de Fuca during summer and fall. The purpose of this study is to help identify elements of toxicity and the environmental parameters that promote growth and expression of toxicity in the raphidophyte *Heterosigma akashiwo*. Various vessels are used and efforts require 20 DAS. Daytime operations only. Water samples are collected for: marine toxins, chlorophyll a, micro and macro nutrients, phytoplankton species ID and enumeration, and DNA analysis. Gear consists of plankton nets and CTD profiler and rosette water sampler. Approximately 70 samples are taken per year.

Long-term Eelgrass Monitoring: This survey would be conducted every three months at sites within Puget Sound proper that are paired across a range of urbanization gradients. The purpose of the survey is to conduct long-term monitoring of fringe eelgrass habitats in Puget Sound. The work will be used to quantify growth, pressures, and community structure of eelgrass beds over the next 20 years to monitor for potential changes due to climatic/oceanic conditions and management actions related to shoreline amoring and land-use practices. Seagrass, sediments, and water samples will be collected to quantify epiphyte loads and sediment quality, and water chemistry. Transects will be used to quantify fish, invertebrate, and eelgrass densities. The vessel used is the R/V *Minnow*. The effort requires 10 DAS. Daytime operations only. SCUBA divers use sediment grabs and Niskin bottles. There will be about 360 transects per year.

Marine Fish Research including Broodstock Collection, Sampling, and Tagging: These surveys occur monthly in Puget Sound. The purpose is to collect fish for broodstock, sampling, and tagging. A chartered sportfishing vessel is used and the duration is about 15 DAS each month. Daytime operations only. Gear used includes a pelagic longline with an approximate 3 hour soak time. Length of the mainline is 750-1000 ft set at 700-3000 fathoms, with 500 barbed circle hooks baited with squid per set. The survey deploys approximately 30 sets per year. Additonal protocols include the use of hook and line gear deployed by rod and reel. Eight anglers with eight lines in the water are fished at a time, using barbed circle hooks. The research involves approximately 6 hours of fishing per day with eight lines in the water for a total of 90 hours per year or 720 hook-hours.

Puget Sound Salmon Contaminant Study: This survey is conducted from May to July in Puget Sound. The survey studies contaminant concentrations in juvenile Chinook salmon from multiple sites in Puget Sound. A 17-ft whaler is used to deploy a 37-m long x 2.4-m wide beach seine with 10-mm mesh size for less than 10 minutes, with up to 100 sets/year. The effort requires 30 DAS and occurs in daytime only.

Snohomish Juvenile Salmon Survey: This survey occurs monthly year-round and twice monthly from February to September in the Snohomish estuary. The purpose is to document juvenile salmon use of the Snohomish estuary and pre-restoration conditions at the Qwuloolt levee breach project and adjacent reference areas. The vessel used is a 17-ft whaler or inflatable. Gear consists of a beach seine with a net size of 140 x 6 ft, mesh size of <1 in, and set for <10 min (up to 200 sets/year), and a fyke net trap with variable net sizes, mesh size of <0.25 in, and set for up to 6 hours (up to 100 sets/year). The fyke nets used are basically block nets that have wings that guide fish into a trap box. Nets are set at high tide and as the tide ebbs, fish are funneled into the trap. Fyke nets are fished in estuarine channels that range in width from 3 ft or less to 15 ft. The effort requires 50 DAS and occurs in daytime only.

Urban Gradient Surveys: These surveys are conducted during the summer at five pairs of study sites in Puget Sound across a range of urbanization. The purpose is to identify relationships between land use practices and the properties of streams and nearshore marine ecosystems around Puget Sound. The goal is to examine how ecosystem structure (the relative abundance of different species) and ecosystem functions (the processes connecting species to one another) vary according to the level of urbanization. The focus is on motile epibenthic invertebrates (e.g. shrimps, gastropods, isopods, and amphipods) from eelgrass habitats. The surveys are done using the R/V *Minnow* or from the shore. The effort requires 10 DAS and occurs in daytime only. The gear consists of an Epibenthic tow sled with a 1 x 1-m mouth opening and 1-mm mesh towed for approximately 10 minutes at 1 m depth. From 3 to 5 samples are taken per site/year; 30-60 samples total.

1.6.3 Surveys Conducted in the Lower Columbia River Research Area (LCRRA)

Studies Using Trawl Gear

Eulachon Arrival Timing: This survey occurs about 6 times between January and March in the Columbia River Estuary and Plume but does not extend out into the CCRA. The purpose is to determine the arrival timing and distribution of spawning eulachon at the mouth of the Columbia River. The survey is conducted on NOAA research vessels using a modified Cobb trawl with 9.5 mm codend towed at 2.7 knots for 15 minutes at 30-40 m depth. The effort requires 15 DAS and occurs in daytime only. Samples will be taken for fecundity and other biological data but most fish will be released unharmed. About 60 trawls will occur per year.

Pair Trawl Columbia River Juvenile Salmon Survey: The survey takes place between March and August in the upper Columbia River Estuary (River Kilometer 65 to 85). The purpose of the survey is to assess passage of tagged juvenile salmon migrating from the upper reaches of the Columbia River basin to the ocean by passively sampling Passive Integrated Transponder (PIT)-tagged juvenile salmonids. Two 41-foot utility vessels are used to deploy the net and tow it plus a small skiff to tend equipment and clear debris. Duration is 80 DAS, 800 - 1200 hours per year. Sampling occurs on a 24-hour basis. Gear used consists of a surface pair trawl with an 8 x 10-ft open cod-end and PIT detector array. The trawl is equipped with 92 x 92-m wings, with a body of 9 m wide x 6 m deep x 18 m long. The trawl is towed at 1.5 kts for 8-15 hours at depths from surface to 5 m. Towed antennae may replace the pair trawl net for PIT detection if development is successful.

Studies Using Other Gears

Benefits of Wetland Restoration to Juvenile Salmon: Action Effectiveness Monitoring: This survey is conducted bi-weekly from March to October in the Columbia River estuary from the river mouth to Bonneville Dam. The purpose is to study is to examine salmon habitat use in the lower Columbia River estuary focusing on determining benefits that juvenile salmon obtain from restoring wetland habitats. The vessel used is the R/V *Pelican* and a skiff. The effort requires 32 DAS and occurs in daytime only. Gear used consists of a 500 x 30 ft purse seine deployed for less than one hour (90/year), 150 x 6 ft beach seine deployed for less than 10 minutes (16 sets/year), trap nets soaked up to six hours (16 sets/year), a CTD profiler (about 90 casts/year), and a 10 x 20 ft surface trawl towed between skiffs for about 15 minutes.

Columbia River Estuary Tidal Habitat: This survey is conducted quarterly to monthly in the Columbia River estuary from the river mouth to Bonneville Dam. The purpose is to study salmon habitat use and genetic stocks of origin. Vessel used is a 17-ft whaler. The effort requires 25 DAS and occurs in daytime only. Gear used consists of a 150 x 6 ft beach seine set for <10 minutes (less than 100/year), Trap nets soaked up to six hours (less than 50 sets/year), CTD (about 100/year), 24-volt backpack shocker and boat electro-shocker (less than 100 sites/year), 6 stationary PIT antennas, fish holding pens, and water level & temperature logger, and insect fall out traps, emergent insect cone traps, and benthic cores.

Effects of Dredging on Crab Recuitment: This survey is conducted periodically between August and October in the nearshore Columbia River mouth area. The purpose is to study how Dungeness crab respond to dredge spoils being placed in nearshore zone for beach nourishment. The MERTS vessel R/V *Forerunner* is used for this study and the duration is 15 DAS annually. Daytime operations only. Gear used includes a Benthic video sled, acoustic telemetry with moored Vemco VR2 receivers and V9-2H transmitters, and a video drop camera system.

Lower Columbia River Ecosystem Monitoring: This survey is conducted monthly from February through December in the lower Columbia River Estuary. The survey studies habitat occurrence and the health of juvenile salmon and their prey. The survey is conducted on a 17-ft whaler. The effort requires 16 DAS and occurs in daytime only. A 37-m long x 2.4-m wide beach seine with 10-mm mesh size is deployed for less than 10 minutes; with up to 200 sets/year. A Neuston plankton net is also deployed for about five minutes, about 50 sets/year.

Migratory Behavior of Adult Salmon: This survey is conducted in the Columbia River Estuary up to the Bonneville dam during spring-fall as needed to meet tagging goals. The objective of the work is to determine the migratory rate of adult Chinook salmon destined for upper river spawning sites. Various commercial fishing vessels are chartered to capture fish with 200-foot-long tangle nets (designed for non-lethal capture). Set duration is 25-45 minutes with up to 75 sets per year. The effort requires 32 DAS and occurs in daytime only.

Pile Dike PIT-Tag Detection System: The detection system is located in the Columbia River Estuary near River Kilometer 70 and is operated from March to October (but may become year-round). The purpose of the system is to detect migrating adult and juvenile salmon. Vessels are only used for servicing the system. The subsurface deployment is continuous during the season. Gear consists of a small guidance net (20 ft x 20 ft) anchored in place leading to an 8 ft x 20 ft (minimum) opening with subsurface PIT-tag detector.

Table 1-1 Summary Descriptions of Surveys Conducted by the Northwest Fisheries Science Center on NOAA Vessels and Chartered Vessels

See Appendix A for descriptions of the different gear types and vessels used. Mitigation measures are described in Section 2.2.1. Abbreviations used in the table: AWT= Aleutian Wing Midwater Trawl; CTD = Conductivity Temperature Depth; DAS = days at sea; cm^2 = square centimeter; freq = frequency; ft = feet; hrs = hours; in = inch; kHz = kilohertz; km = kilometer; kts = knots; L = liter; m = meter; m^3 = cubic meter; max = maximum; MHz = megahertz; mi = miles; min = minutes; mm = millimeter; NA = Not Available or Not Applicable; nm = nautical miles; TBD = to be determined; v = volt; yr = year; ~ = approximately.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
CALIFORNIA CURRENT RESEARCH AREA								
Studies Using Trawl Gear								
Bycatch Reduction Research	Research effort to test gear improvements to reduce bycatch of non-target fish species. Current examples include testing low-rise bottom trawls, flexible sorting grates in bottom and midwater trawls, and open escape window bycatch reduction devices in midwater trawls.	Southern Oregon to Canada	April - October, Intermittent, 30-90 DAS Daytime operations only	Chartered commercial fishing vessels	Bottom trawl	Net type: Commercial bottom trawls Net size: Varies with vessel Tow speed: 1.5-3.5 kts Duration: up to 4 hrs Depth: 50-1000 m	40 bottom trawls/yr	**Standard Avoidance:** Vessel captains and bridge crew watch for marine mammals and sea turtles while underway, especially where concentrations of protected species are observed, and take action to avoid collisions if possible. **Move-on Rule:** Vessel captains, Chief Scientists, and/or designated members of the scientific party visually monitor the area for protected species at least 10 min before the set and during the set. If marine mammals are too close to the ship or look like they are closing, gear deployment is delayed until the animals leave or the sampling station is moved. If protected species are sighted during the set, set duration, retrieval time, and vessel speed are adjusted as needed to minimize the risk of incidental take (see Section 2.2.2).
					Midwater trawl	Net type: Commercial pelagic trawls Net size: Varies with vessel Tow speed: 1.5-3.5 kts Duration: up to 8 hrs but average 2 hrs Depth: 50-1000 m	up to 60 midwater trawls/yr	
					Bottom trawl	Net type: Double rigged shrimp trawl Net size: Varies with vessel Tow speed: 1.5-3.5 kts Duration: 30-80 min Depth: 100-300 m	up to 60 shrimp trawls/yr	
					Various models of echosounders and sonars	38-200 kHz; ≤ 224 dB/1μPa	Continuous during cruise	
Camera Trawl Research *(Associated with hake acoustic survey)*	Research and development and pilot surveys to refine the development of optical-trawl samplers as applied to acoustical and other surveys, including testing of hardware and software, to assess abundance and species composition in trawls used to sample commercially important groundfish along the U.S. West Coast.	Southern California to Southeast Alaska, including Canada	Annually since 2011, March-Sept, 30-70 DAS Daytime operations only	NOAA Ship R/V *Bell M. Shimada* and charter commercial fishing vessel	Midwater trawl	Net type: Aleutian Wing Midwater Trawl (AWT); Net size: headrope 334 ft Tow speed: 2.8-3.5 kts Duration: variable Depth: down to 500 m	75 trawls/yr (in addition to trawls conducted as part of hake survey)	Standard avoidance and move-on rule.
Flatfish Broodstock Collection	Collection of fish for broodstock for aquaculture development by trawls, hook and line, and various methods.	Puget Sound and Washington coast	Intermittent, up to 20 times annually, 20 DAS Daytime operations only	Charter fishing vessel, NOAA small boats	Bottom trawl	Net type: Commercial bottom trawl Net size: Varies Tow speed: < 3.5 kts Duration: 10 min Depth: > 10 m	6-24 trawls	Standard avoidance and move-on rule.
					Hook and line	Up to 12 lines in the water at once. Barbed circle hooks	18 trips/yr, total hook-hrs depend on targeted species and catch per unit effort	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Groundfish Bottom Trawl Survey	Fisheries independent survey to monitor groundfish distribution and biomass along the U.S. West Coast at depths of 55 to 1280 m.	U.S./Mexico to U.S./Canada border	Annually, May to October, at least 190 DAS Daytime operations only	Charter, two commercial trawlers for each sampling period	Bottom trawl	Net type: modified Aberdeen bottom trawl with video camera Net size: mouth opening 5 x 15 m Tow speed: 2.2 kts Duration: 15 min Depth: 55-1280 m	737-773 trawls/yr	Standard avoidance and move-on rule.
					Various models of echosounders and sonars	27-200 kHz; ≤ 224 dB/1µPa	Continuous during cruise	
					CTD profiler	Gear Type: Sea-Bird SBE 19+ conductivity, temperature, depth profiler equipped with SBE 43 type oxygen sensor; Surface to near bottom and along tow track	737-773 samples/yr	
Hake Acoustic Survey	Measures the abundance of hake using acoustic gear and trawl to confirm identification of fish targets. Use of broadband acoustics to assist in classifying mixed schools acoustically.	Southern California to Southeast Alaska, including Canada, following the hake	Annually, June-Sept, 60-80 DAS Daytime operations only	NOAA Ships R/V Miller Freeman or R/V Bell M. Shimada	Midwater trawl	Net type: AWT Net size: : headrope 334 ft Tow speed: 2.8-3.5 kts Duration: variable Depth: 30-1500 m	150 trawls/yr	Standard avoidance and move-on rule.
					Bottom trawl	Net type: Poly Nor'easter Bottom Trawl (PNE) Net size: footrope 120 ft, headrope 89 ft Tow speed: 2.8-3.5 kts Duration: variable Depth: variable	5-10 trawls/yr	
					Various models of echosounders and sonars	1.5-200 kHz; ≤ 224 dB/1µPa	Continuous during cruise	
					CTD profiler	Gear Type: Sea-Bird SBE 19+ conductivity, temperature, depth profiler equipped with SBE 43 type oxygen sensor; Surface to near bottom and along tow track	150 casts/yr	
Juvenile Salmon PNW Coastal Survey	Assesses Pacific Northwest Coastal ocean condition and the growth, relative abundance, and survival of juvenile salmon during their first summer at sea.	Newport, OR to Cape Flattery, WA in Continental shelf waters	May, June, and September, Annually, 36 DAS (roughly divided equally between May, June and Sept) Daytime operations only	Charter commercial fishing vessel	Surface trawl	Net type: Nordic 264 surface trawl with marine mammal excluder device Net size: 30 m wide x 20 m deep Tow speed: 3 kts Duration: 30 min Depth: surface down to 30 m 4 acoustic pingers attached to the net	180 trawls/yr	Standard avoidance and move-on rule. Marine mammal excluder device consists of rigid grate and escape hatch (orientation and deployment details still under development). Typically two models of pingers with different frequencies are used on each net to deter small cetaceans.
					CTD profiler and rosette water sampler	Gear Type: Sea-Bird SBE 19+ and SBE 23 CTDs Deployment: Vertical drop Depth: Surface to near bottom or 200 m max.	180 samples/yr	
					Bongo net	Net type: Bongo plankton net with 335 µm mesh Net size: two 0.6 m diameter nets Tow speed: 3 kts Duration: 5-6 min Depth: 0-30 m	180 samples/yr	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					Vertical plankton net	Net type: ring net with 202 µm mesh Net size: 0.5 m diameter Tow speed: 0 (vertical tow) Duration: 5-6 min Depth: Surface to near bottom or 100 m max	180 samples/yr	
					Water pump	Gear type: Continuous water pump with SBE-45 MicroTSG Thermosalinograph Depth: 3 m	Continuous during cruise	
Marine Fish Broodstock Collection, Sampling, and Tagging	Collection of fish for broodstock collection, sampling, tagging.	Washington coast	Annual, varied timing, 10 DAS Daytime operations only	Charter fishing vessel	Bottom trawl	Net type: Commercial bottom trawls Net size: Varies Tow speed:1.5-3.5 kts Duration: up to 4 hrs Depth: 50-1000 m	10 trawls/yr	Standard avoidance and move-on rule.
					Pelagic longline	Mainline length: 750-1000 fathoms Depth: 700-3000 ft Gangion length: Snap gear less than 1 ft Gangion spacing: ~10 ft apart Hook size and type: Circle hooks, barbed # of hooks and bait: 500 hooks/set; squid Soak time: ~3 hrs	30 sets/yr	Standard avoidance and move-on rule. No bait or offal discarded before or during sets.
					Hook and line gear deployed by rod and reel	Eight anglers with eight lines in the water at a time. Barbed circle hooks	6 hrs fishing per day, 90 hrs total, 720 hook-hrs/yr.	
Northern Juvenile Rockfish Survey	Measures the spatial abundance of juvenile fishes in coastal marine waters of the northern California Current ecosystem as an index of groundfish recruitment potential	Cape Mendocino, CA to Cape Flattery, WA	Annually, May-June, 15-30 DAS Night operations only	Charter commercial fishing vessel	Midwater trawl	Net type: Modified Cobb trawl with 9.5 mm codend Net size: 26 m headrope, opening 12 x 12 m Tow speed: 2.7 kts Duration: 15 min, Depth: 30-40 m	100 trawls/yr	Standard avoidance and move-on rule.
					CTD profiler	Tow speed: 0 Duration: 20-120 min	100 samples/yr	
					Various plankton nets (Bongo and Tucker)	Tow speed: 1.5- 2.5 kts Duration: 20-60 min	100 samples/yr	
					Simrad EK60 Multi-frequency echosounder	38, 70, 120, and 200 kHz; 228 dB/1µPa	Continuous during cruise	
Video Beam Trawl Collaborative Research	Survey along the continental shelf to assess the seasonal and interannual distribution of young of the year groundfishes and the potential impacts of hypoxia.	Oregon to Washington	Monthly (variable), 20 DAS Daytime operations only	University research vessels or chartered commercial fishing vessel	Bottom video beam trawl system	2 m beam trawl with digital video camera system Tow speed: 1-1.5 kts Duration: 10 min	20 - 40 deployments	Standard avoidance and move-on rule. Open codend on trawl, camera documents what goes in but there is no catch.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Studies Using Other Gears								
Coastwide Groundfish Hook and Line Survey in Untrawlable Habitat *(This is an expanded effort version of the Southern California Groundfish Hook and Line Survey)*	Hook and line survey to monitor groundfish distribution and abundance along the U.S. West Coast expanded coastwide and nearshore	US-Canada to US-Mexico border	Annually, May - Oct., 250 DAS Daytime operations only	Charter sportfishing vessels (3 to 4 vessels)	Hook and line gear deployed by rod and reel	Hooks: 3 anglers; 5 hooks per line; 5 sets per angler per site (75 total hooks per site) Soak time: 5 min soak time per set Depth: 15-250 m	1000 sites, 75,000 hooks total	Standard avoidance and move-on rule. No bait or offal discarded before or during sets. Gear lightweight and unlikely to entangle marine mammals
					Camera sled and drop cameras	Tethered video camera	1000 deployments	
					CTD profiler	Deployment: Vertical drop	1000 casts	
					Furuno echosounder	38, 70, 120, and 200 kHz	continuous	
Near Coastal Ocean Purse Seining	Study of salmon habitat use in offshore areas of the lower estuary, near the mouth, and in nearshore areas of the ocean near the Columbia River.	Nearshore near the mouth of the Columbia River	Monthly, May-Sept, 12 DAS Daytime operations only	Chartered commercial fishing vessel	Purse seine	Net type: Purse seines Net size: 750 x 60 ft or 1000 x 40 ft Mesh size: 0.625 in (net body); 1.3 in (tow end); 0.45 in (bunt) Set duration: Generally < 1 hr	75 sets/yr	The net will not be set around pinnipeds but may be set if only a few are visible in the area. Pinnipeds are often attracted to the net and easily jump into and out of the net; the net will not be opened if only pinnipeds enter it. If any dolphins or porpoises are seen within 500 m, the move-on rule is applied. If killer whales are seen at any distance, the move-on rule is applied. If any cetaceans are seen within the net it is opened immediately.
Newport Line Plankton Survey	Survey along the Newport Hydrographic Line to assess oceanographic conditions and zooplankton species composition and abundance	Newport Hydrographic Line, Oregon	Bi-Weekly 24-hr operations	R/V *Elakha*, owned and operated by Oregon State University	Bongo net	Net type: Bongo plankton net with 335 µm mesh Net size: two 0.6 m diameter nets Tow speed: 2 kts Duration: 5-6 min Depth: 0-30 m	150 samples/yr	Standard avoidance
					Vertical plankton net	Net type: ring net with 202 µm mesh Net size: 0.5 m diameter Tow speed: 0 (vertical tow) Duration: 5-6 min Depth: Surface to near bottom or 100 m max	150 samples/yr	
					CTD profiler and Niskin bottles	Gear Type: Sea-Bird SBE 25 CTD, Deployment: Vertical drop Depth: Surface to near bottom or 200 m max	150 samples/yr	
					Multi-frequency active acoustics	38, 70, 120, and 200 kHz (Simrad EK60)	Continuous during cruise	
Northern California Current Ecosystem	Periodic survey of oceanographic conditions in the Northern	Off coasts of Washington and	Approximately every other year,	NOAA vessels R/V *Bell M.*	Vertical plankton nets	Vertical drop, variable depth	Varies with ship time	Standard Avoidance

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					Bongo net	Net type: Bongo plankton net with 335 µm mesh Net size: two 0.6 m diameter nets Tow speed: 2 kts Duration: 5-6 min Depth: 0-30 m	Varies with ship time	
					CTD profiler and rosette water sampler	Gear Type: Sea-Bird SBE 19+ CTD, Deployment: Vertical drop Depth: Surface to near bottom or 200 m max	Varies with ship time	
PNW Harmful Algal Bloom Survey	Survey along the Oregon and Washington coast to assess oceanographic conditions and phytoplankton species composition and abundance with an emphasis on harmful algal species. Samples collected for: Marine toxins, chlorophyll a, micro and macro nutrients, phytoplankton species ID and enumeration, DNA analysis, and dissolved oxygen	Oregon to Washington	Summer, Fall, Annual, minimum of 10 DAS 24-hr operations	Vessels range from ocean-going research ships to small open skiffs. Size range 15-275 ft	Plankton nets	2 ft long, 20 µm mesh nets deployed by hand over the side of the vessel. Net samples only surface waters (0-2 m)	~200/cruise	Standard avoidance
					CTD profiler and rosette water sampler	Gear Type: Sea-Bird SBE 9/11+ Deployment: Vertical drop Depth: Surface to near bottom or 500 m max	~200/cruise	
Technology Development Research	Develop alternative sampling methodologies using autonomous underwater vehicles to assess groundfish abundance and distribution using video capturing equipment.	Washington to California	Summer and Fall, up to 20 DAS Daytime operations only	Chartered vessels, UNOLs vessels, NOAA vessels (R/V *Bell M. Shimada*)	Autonomous underwater vehicle and associated equipment	AUV (Autonomous Underwater Vehicle), one of which is called Lucille. It is not tethered and is piloted remotely. It is several meters long. Dives have been up to 2000 ft deep. It is used with multiple objectives.	No sampling other than video. Number of dives varies by scientific objective; up to 17 dives per cruise.	Standard avoidance
PUGET SOUND RESEARCH AREA								
Studies Using Trawl Gear								
Beam Trawl Survey to Evaluate Effects of Hypoxia	Examined the effects of hypoxia on demersal fish in Hood Canal. A camera was mounted onto a beam trawl and the video was reviewed to measure escape response time to the bottom trawl by various bottomfish.	Five sites in southern Hood Canal and five sites in northern Hood Canal	Summer-Fall, 20 DAS Daytime operations only	Chartered vessels	Beam trawl with video camera, primarily with open cod end. A few tows have a closed cod-end to verify species composition identified in the video.	Net type: beam trawl Net size:2 m wide, towed along the bottom at varying depths (30, 60 and 90 m) Duration: 10 min.	One tow per site per season, 20 tows total.	Standard avoidance and move-on rule
					CTD profiler	Deployment: Vertical drop	20 casts	
Marine Fish Collections Including Flatfish	Collection of marine fish for research including broodstock.	Puget Sound	Annual, varies, monthly, 15 DAS Daytime operations only	Charter vessel	Bottom trawl	Net type: Commercial bottom trawls Net size: Varies Tow speed: 1.5-3.5 kts Duration: up to 4 hrs Depth: 50-1000 m	40 bottom trawls/yr	Standard avoidance and move-on rule
Movement Studies of Puget Sound Species	Various types of studies of fish movement in Puget Sound using telemetry. Involves live-capture with various gears and SCUBA divers, tagging and release of species, and placement of	Puget Sound	Year round sampling, 25 DAS Daytime operations only	A variety of small boats, such as Whalers. Charter boats used for hook and line, purse	Bottom trawl	Net type: Commercial bottom trawls Net size: Varies Tow speed: < 3.5 kt Duration: 10 min Depth: > 10 m	12/yr	Standard avoidance and move-on rule

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
	detection arrays. Species include sixgill shark, Chinook and Coho salmon, lingcod, ratfish, steelhead, English sole, canary and yellow-eye rockfish, spiny dogfish, sunflower stars, and jellyfish.			seines and trawls depending on the circumstances.	Purse seines	Net type: herring seine Net size: 1500 x 90 ft Mesh size: variable Set duration: < 1 hr Depth: < 50 m	12/yr	The net will not be set around pinnipeds but may be set if only a few are visible in the area. Pinnipeds are often attracted to the net and easily jump into and out of the net; the net will not be opened if only pinnipeds enter it. If any dolphins or porpoises are seen within 500 m, the move-on rule is applied. If killer whales are seen at any distance, the move-on rule is applied. If any cetaceans are seen within the net it is opened immediately.
					Hook and line	Up to 12 lines in the water at once. All hooks are barbless.	20 trips per yr	Barbless hooks. No chumming. Avoid interactions with killer whales by not fishing if they are seen at any distance.
					Demersal longline	Mainline: 600 ft Depth: about 200 ft 30 hooks/set Hooks: 16/0 circle Soak time: 90 min	3 sets, 90 hooks total	Visual monitoring of area before and during the set, avoid killer whales as above.
					SCUBA divers	Divers capture jellies and stars by hand	One collection tripper site	
					VR2 passive acoustic receivers	VR2s moored on bottom with metal weights (no lines) and acoustic releases in deep water near fishing location	Continuous for season	
Puget Sound Marine Pelagic Food Web	Study of the marine pelagic food web in Puget Sound focusing on the effects of land use and development of the food web.	Puget Sound	About every 5 years as funding is available, April to October, 30 DAS Daytime operations only	Chartered vessels	Surface trawl	Net type: Kodiak surface trawl Net size: 3.1 x 6.1 m Tow speed: 1.8-2.2 kts Duration: 10 min Depth: < 10 m	500 trawls; survey every 5 years	The low towing speeds, small net opening, and fine mesh netting make it a near certainty that we would not catch any marine mammals. Pinnipeds are often in the areas where we sample with this gear. Maintain a watch for cetaceans. If any dolphins or porpoises are seen within 500 m, the move-on rule is applied. If killer whales are seen at any distance, the move-on rule is applied.
Skagit Bay Juvenile Salmon Survey	Assesses coastal ocean conditions in Puget Sound and the growth, relative abundance, and survival of juvenile salmon during their first summer at sea.	Puget Sound	Annually, April to September, 30 DAS Daytime operations only	Chartered vessels	Surface trawl	Net type: Kodiak surface trawl Net size: 3.1 x 6.1 m Tow speed: 1.8-2.2 kts Duration: 10 min Depth: < 10 m	180 trawls/yr	The low towing speeds, small net opening, and fine mesh netting make it a near certainty that we would not catch any marine mammals. Pinnipeds are often in the areas where we sample with this gear. We maintain a watch for cetaceans. If any dolphins or porpoises are seen within 500 m, the move-on rule is applied. If killer whales are seen at any distance, the move-on rule is applied.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Studies Using Other Gears								
Elwha Dam Removal	Study of potential effects of dam removal on nearshore fish including ESA listed species.	Puget Sound	Monthly, 2006 to present, 20 DAS Daytime operations only	17 ft Whaler	Beach seine	Net type: Beach seine Net size: 140 x 6 ft Mesh size: < 0.25" Duration: < 10 min	up to 140 samples/yr	Visual monitoring of area, "move on" rule if marine mammals are within 100 m of a sampling site
ESA-listed Rockfish Genetics	This project collects fin clips from all bottomfish captured during hook-and-line fishing with a focus on locating and getting genetic samples from ESA-listed rockfish species (yelloweye, canary, and bocaccio rockfish). These are not standardized surveys to quantify abundance or density estimates, but are being used to collect size, weight, location, depth, and genetic information from bottom fish species. The intent is to release all fish unharmed.	Puget Sound, San Juan Islands and the Strait of Juan de Fuca	April to November, 35-41 DAS Daytime operations only	Charter boats: *F/Vs Joker, Venture, Dash One, All Star, Morning Star, Fishfull Thinking II, Malia Kai, Cabazon, Darla Orion, Ann Patrice*	Hook and line fishing gear - bait and jigs	Hook and line fishing with bait (herring and squid) or bottom jigs such as darts. Average 4 hooks per day for 18.2 hook-hours per day.	Approximately 750 hook-hours per year with target numbers of fishes in each area.	Standard avoidance Capture and processing of ESA-listed fish is authorized under an ESA section 10 directed research permit.
Herring Egg Mortality Survey	Explores spatial variation and drivers of herring egg loss in Puget Sound. Investigating if herring egg loss relates to vegetation types used by herring for spawning substrate, the presence of suspected large herring egg predators (diving ducks and large fish), and metrics of shoreline development.	Herring spawning locations in Puget Sound <10m deep. Iincludes: Squaxin Pass, Quartermaster Harbor, Elliot Bay, Port Orchard, Quilcene Bay, Holmes Harbor, Cherry Point.	February-May, 2013 and future, 20 DAS Daytime operations only	R/V *Minnow* (F2113) and R/V *Noctiluca* (F2606)	SCUBA divers, predator exclusion cages	Egg collections by hand. Cages are modified conical sablefish pots with doors sewed shut and bottom closure removed. Mesh openings ~ 3 x 3 cm. Cages deployed at first visit and retrieved on the last visit to each site (~ 10 days)	~ 600 small vegetation samples with herring eggs taken from each site per year.	Standard avoidance
Heterosigma akashiwo **Bloom Dynamics and Toxic Effects**	Identify elements of toxicity and the environmental parameters that promote growth and expression of toxicity in the raphidophyte Heterosigma akashiwo. Water samples collected for: marine toxins, chlorophyll a, micro and macro nutrients, phytoplankton species ID and enumeration, and DNA analysis.	Puget Sound, Georgia Strait, Strait of Juan de Fuca	Summer, Fall, 20 DAS Daytime operations only	Various	Plankton nets	20 µm mesh nets deployed by hand over the side of the vessel. Net samples only surface waters (0-2 m)	~70/yr	Standard avoidance
					CTD profiler and rosette water sampler	Gear Type: Sea-Bird SBE 19 CTD Deployment: Vertical drop by hand Depth: Surface to near bottom or ~35 m max	~70/yr	
Long-term Eelgrass Monitoring	We will begin long-term monitoring of fringe eelgrass habitats in Puget Sound in 2015. This work will be used to quantify growth, pressures, and community structure of eelgrass beds over the next 20 years to monitor for potential changes due to climatic/oceanic conditions and management actions related to shoreline armoring and land-use practices.	Sites will be within Puget Sound proper and will be paired across a range of urbanization gradients.	Quarterly beginning in 2015, 10 DAS Daytime operations only	R/V *Minnow* (F2113)	SCUBA divers, sediment grabs, and water samples in niskin bottles	Transects will be used to quantify fish, invertebrate, and eelgrass densities. Collection of seagrass, sediments, and water samples will be used to quantify epiphyte loads and sediment quality, and water chemistry.	4 transects per site (~5 sites) each quarter = 360 transects per year	Standard avoidance

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Marine Fish Research Including Broodstock Collection, Sampling, and Tagging	Collection of fish for broodstock, sampling, and tagging.	Puget Sound	Annually, timing varies monthly, 15 DAS Daytime operations only	Charter sportfishing vessel	Pelagic longline	Mainline length: 750-1000 fathoms Depth: 700-3000 ft Gangion length: Snap gear less than 1 ft Gangion spacing: ~10 ft apart Hook size and type: Barbed circle hooks Number of hooks and bait: 500 hooks/set; squid Soak time: ~3 hrs	30 sets/yr	Standard avoidance and move-on rule. No bait or offal discarded before or during sets.
					Hook and line gear deployed by rod and reel	Eight anglers with eight lines in the water at a time, barbed circle hooks	6 hrs fishing per day, 90 hrs total	
Puget Sound Salmon Contaminant Study	Study of contaminant concentrations in juvenile Chinook salmon from multiple sites in Puget Sound	Puget Sound	May-July, 30 DAS Daytime operations only	17 ft Whaler	Beach seine	Net type: Beach seine Net size: 37 m long by 2.4 m wide Mesh size: 10 mm Set duration: < 10 min	up to 100 sets/yr	Seine not deployed within 200 m of hauled out pinnipeds. Site continually monitored.
Snohomish Juvenile Salmon Studies	Beach seine and fyke trap sampling of fish assemblages to document juvenile salmon use of the Snohomish estuary and pre-restoration conditions at the Qwuloolt levee breach project and adjacent reference areas.	Snohomish Estuary	Monthly year-round; twice monthly from Feb-Sept. Pole seine monthly from Oct to May, 50 DAS Daytime operations only	17 ft Whaler or inflatable	Beach seine	Net type: Beach seine Net size: 140 x 6 ft Mesh size: < 1” Duration: < 10 min	up to 200 sets/yr	Seine not deployed within 200 m of hauled out pinnipeds. Site continually monitored.
					Fyke trap	Net type: Barrier trap set across small tidal channels Net size: 3-15 ft depending on channel Mesh size: < 0.25” Duration: up to 6 hrs	Up to 100 sets/yr	
					CTD profiler	Deployment: Vertical drop	100 casts	
Urban Gradient Surveys	Purpose is to identify relationships between land use practices and the properties of streams and nearshore marine ecosystems around Puget Sound. Goal is to examine how ecosystem structure (the relative abundance of different species) and ecosystem functions (the processes connecting species to one another) vary according to the level of urbanization. Focus is on motile epibenthic invertebrates (e.g., shrimps, gastropods, isopods, amphipods) from eelgrass habitats.	Central Puget Sound; five pairs of study sites across a range of urbanization. (See http://www.nwfsc.noaa.gov/research/divisions/cb/ecosystem/nearshore/psug/studysites.cfm for map)	Summer, starting in 2011, 10 DAS Daytime operations only	R/V *Minnow* (F2113) or shore access	Epibenthic tow sled	1 m x 1 m mouth opening, 1 mm mesh Duration: 10 min tows in eelgrass beds at 1 m depth.	3-5 samples per site per year, 36-60 samples total	Standard avoidance

<table>
<tr><th>Survey Name</th><th>Survey Description</th><th>General Area of Operation</th><th>Season, Frequency, Yearly Days at Sea (DAS)</th><th>Vessel Used</th><th>Gear Used</th><th>Gear Details</th><th>Number of Samples</th><th>Mitigation Measures</th></tr>
<tr><td colspan="9">LOWER COLUMBIA RIVER RESEARCH AREA</td></tr>
<tr><td colspan="9">Studies Using Trawl Gear</td></tr>
<tr><td rowspan="2">Eulachon Arrival Timing</td><td rowspan="2">Determine the arrival timing and distribution of spawning eulachon at the mouth of the Columbia river. Samples will be taken for fecundity and other biological data but most fish will be released unharmed.</td><td rowspan="2">Columbia River Estuary and Plume</td><td rowspan="2">January to March (about 6 times), 15 DAS
Daytime operations only</td><td rowspan="2">NOAA R/Vs Magister and Murrelet</td><td>Midwater trawl</td><td>Net type: Modified Cobb trawl with 9.5 mm codend
Net size: 26 m headrope, opening 12 x12 m
Tow speed: 2.7 kts
Duration: 15 min, Daytime tows
Depth: 30-40 m</td><td>60 trawls/yr</td><td rowspan="2">Standard avoidance and move-on rule.</td></tr>
<tr><td>CTD profiler</td><td>Deployment: Vertical drop</td><td>60 casts</td></tr>
<tr><td>Pair Trawl Columbia River Juvenile Salmon Survey
(A towed antennae may replace the pair trawl net for PIT detection if technology successfully developed)</td><td>A surface pair trawl with a flow-through PIT tag detector is used to assess passage of tagged juvenile salmon migrating from the upper reaches of the Columbia River basin to the ocean.</td><td>Columbia River Estuary (River Kilometer 65 to 85)</td><td>March to August, 1000 hrs/yr, 80 DAS
24-hr operations</td><td>Two 41 ft utility vessels to deploy net and tow plus a small skiff to tend equipment and clear debris</td><td>Surface pair trawl (a surface trawl with two mesh wings leading to an open cod-end with a PIT detector array)</td><td>Net type: Surface trawl modified with open cod end (8 x 10 ft opening)
Net size: wings 92 m x 92 m, trawl body 9 m wide x 6 m deep x 18 m long
Mesh size: wings 3.8 cm, body 1.8 cm. Tow speed: 1.5 kts
Duration: 8-15 hrs
Depth: surface to 5 m</td><td>800 - 1200 hrs/yr</td><td>Use of deterrence devices on nuisance pinnipeds; use of a skiff and pyrotechnics (e.g. poppers and screamers) to drive animals from the trawl area and seal bombs once animals are outside of the trawl. The PIT-tag detector is at the open cod end therefore marine mammals can pass through the net and exit through the detector array if they get that far inside.</td></tr>
<tr><td colspan="9">Studies Using Other Gears</td></tr>
<tr><td rowspan="5">Benefits of Wetland Restoration to Juvenile Salmon: Action Effectiveness Monitoring</td><td rowspan="5">Study of salmon habitat use in the lower Columbia River estuary focusing on determining benefits that juvenile salmon obtain from restoring wetland habitats.</td><td rowspan="5">Columbia River Estuary, Bonneville Dam to mouth</td><td rowspan="2">Bi-weekly, March to October, 32 fishing days
Daytime operations only</td><td rowspan="2">R/V Pelican and a skiff</td><td>Purse seine</td><td>Net type: Purse seine
Net size: 500 x 30 ft
Mesh size: 0.34 in (net body), 0.25 in (bunt)
Set duration: Generally < 1 hr</td><td>90 sets/yr</td><td rowspan="5">Estuary sampling stations are fixed and avoid haul out areas of pinnipeds. The net will not be set around pinnipeds but may be set if only a few are visible in the area. Pinnipeds are often attracted to the net and easily jump into and out of the net; the net will not be opened if only pinnipeds enter it. If any dolphins or porpoises are seen within 500 m, the move-on rule is applied. If killer whales are seen at any distance, the move-on rule is applied. If any cetaceans are seen within the net it is opened immediately.</td></tr>
<tr><td>CTD profiler</td><td>Gear Type: Sea-Bird SBE 19+ CTD
Deployment: Vertical drop
Depth: Surface to near bottom or 20 m max.</td><td>90 samples/yr</td></tr>
<tr><td rowspan="3">Quarterly, March to December
Daytime operations only</td><td>17 ft Whaler</td><td>Beach seine</td><td>Net type: beach seine
Net size: 150 x 6 ft
Mesh size: < 1 in
Set duration: < 10 min</td><td>Two sites per day. Two to three hauls per site. 16 sampling days per year.</td></tr>
<tr><td>17 ft Whaler</td><td>Trap nets</td><td>Net type: barrier trap
Net size: variable
Mesh size: < .25 in
Set duration: up to 6 hrs soak time</td><td>Two sites per day. Two to three hauls per site. 16 sampling days per year.</td></tr>
<tr><td>Two small boats, 17 ft Whaler sized boat plus larger tow boat.</td><td>Small surface trawl</td><td>Net type: surface trawl
Net size: 10 x 20 ft
Mesh size: 1.0 in (net body), 0.5 inch bag
Set duration: Generally 15 minutes</td><td>Two sites per day. Two to three hauls per site. 16 sampling days per year.</td></tr>
<tr><td>Columbia River Estuary Tidal Habitats</td><td>Study of salmon habitat use and genetic stocks of origin throughout the estuary from the river mouth to Bonneville.</td><td>Columbia River Estuary</td><td>Quarterly to monthly, 25 DAS
Daytime</td><td>17 ft whaler</td><td>Beach seine</td><td>Net type: Beach seine
Net size: 150 x 6 ft
Mesh size: < 1”
Set duration: < 10 min</td><td>< 100/yr</td><td>Standard avoidance and move-on rule.</td></tr>
</table>

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
			operations only		Trap nets	Net type: barrier trap Net size: variable Mesh size: < 25” Set duration: up to 6 hrs soak time	< 50 sets/yr	
					CTD	Gear Type: Sea-Bird SBE 19+ CTD, WETstar fluorometer, C-Star transmissometer, and Sea-Bird SBE 43 dissolved oxygen sensor Deployment: Vertical drop Depth: Surface to near bottom or 200 m max."	~100/yr	
					Electro-fishing	Gear types: 24-volt backpack shocker (shallow tidal fresh wetlands and floodplains); Boat electro-shocker (100 m transects, tidal-fresh channels and backwater areas)	<100 sites/yr	
					Remote PIT detection	Gear types: ≤ 6 stationery PIT antennas (up to 4 ft x 10 ft each) per tidal channel	Continuous operation, ≤ 8 sites/year	
					Fish holding pens	<0.25 in mesh, 10ft x 10 ft x 6ft or smaller for holding fish in flooded wetlands	Episodic, <6 months/yr, 4 sites	
					Water level & temperature logger	Hobo U-model and tidbit	Continuous operations; ~12 sites/year	
					(1) Insect fall out traps, (2) emergent insect cone traps, and (3) benthic cores	(1) staked plastic tubs (50 cm x 35 cm x 14 cm) with <10% dishsoap solution; (2) plastic inverted conical traps (0.6 m^2); and (3) 0.0024 m^2 sediment cores	monthly year round, up to 8 sites, at least 5 replicates per site	
Effects of Dredging on Crab Recruitment	Study of how Dungeness Crab respond to dredge spoils being placed in nearshore zone for beach nourishment	Nearshore Columbia River Mouth Area	Periodic, August to October, 15 DAS Daytime operations only	MERTS vessel R/V *Forerunner*	Video ROV	Benthic video sled	~ 15 days at sea	Standard avoidance
					Acoustic telemetry	Moored Vemco VR2 receivers, V9-2H transmitters	8 receivers; 30-60 tags/yr	
					"CamPod"	Video drop camera	5-6 replicate deployments	
Lower Columbia River Ecosystem Monitoring	Study of habitat occurrence and health of juvenile salmon and their prey in the Lower Columbia Estuary	Columbia River Estuary	Monthly, February-December, 16 DAS Daytime operations only	17 ft whaler	Beach seine	Net type: Beach seine Net size: 37 m long x 2.4 m wide Mesh size: 10 mm Set duration: < 10 min	up to 200/year	Standard avoidance and move-on rule
					Plankton net	Net type: Neuston net Net size: 1 x 3 m Mesh size: 250 micrometer Tow duration: ~ 5 min	50 /year	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	*Vessel Used*	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Migratory Behavior of Adult Salmon	The objective of the work is to catch fish unharmed and to tag and release them in order to determine the migratory rate of adult Chinook salmon destined for upper river spawning sites. Study conducted by cooperative research partners affiliated with commercial fisheries.	Columbia River Estuary (to Bonneville Dam)	Spring to fall, As needed to make tagging goals, 32 DAS Daytime operations only	Various commercial fishing vessels	Tangle net (designed for non-lethal capture of fish) Catch, tag, and release only.	Net type: Tangle net Net size: 600 x 40 ft Mesh size: 4.25" Duration: 25-45 min	up to 75 sets/yr	Avoid fishing near seal and sea lion haul out areas, reduce soak times if mammals present, use of a net that marine mammals can tear (i.e., not catch themselves). Use of skiff to patrol net and deter pinnipeds through boat/human presence, use of pyrotechnics (e.g. bangers and screamers) if nuisance pinnipeds approach within 200 yards, use of seal bombs if pinnipeds approach within 20 yards but not closer than 6 ft.
Pile Dike PIT-Tag Detection System	Deploy a PIT-tag detector on a pile dike to detect migrating adult and juvenile salmon.	Columbia River Estuary (near River Kilometer 70)	March to October with potential for year round 24-hr operations	Vessels are only used for servicing	Small guidance net (20 x 20 ft) anchored in place leading to an 8 x 20 ft (minimum) opening with subsurface PIT-tag detector	Net type: 18" square mesh of bright orange twine Continuous subsurface deployment during season	Continuous operation	The size and location of the guidance net is fixed (i.e., it is not towed) and it serves to guide fish to the PIT-tag detector opening. Therefore marine mammals can pass along the wing and through the opening.

2.0 THE DATE(S) AND DURATION OF SUCH ACTIVITY AND THE SPECIFIC GEOGRAPHICAL REGION WHERE IT WILL OCCUR

2.1 Dates and Duration of Activities

Table 1-1 is a summary of regularly occurring NWFSC surveys conducted on NOAA owned and chartered vessels. These surveys are likely to continue during the next five years, although not necessarily every year.

Some research projects last multiple years or may continue with modifications (i.e., expansion into other areas). Other projects may only last one year and are not continued. Therefore, not all of the projects summarized in Table 1-1 are likely to continue in the future. Some of the projects that will occur over the period of the MMPA LOA may depend on competitive grant processes and congressional funding levels for the NWFSC, which are inherently uncertain.

- While some surveys are consistently conducted every year (Table 1-1), they are often based on randomized sampling designs so the exact location of survey effort varies year to year in the same general area.
- Some surveys are only conducted every two or three years or when funding is available. Timing of the surveys is a key element of their design but sea and atmospheric conditions as well as ship contingencies often dictate what can happen on any given day or whether scheduled surveys actually occur so there is variability inherent in even the most consistently conducted surveys.
- In addition, the research program is designed to provide flexibility on a yearly basis in order to address issues as they arise.

2.2 Geographic Region Where the Activity Will Occur

NWFSC research is conducted in three research areas: the California Current Research Area (CCRA; Figure 1-2), Puget Sound Research Area (PSRA; Figure 1-3), and the Lower Columbia River Research Area (LCRRA; Figure 1-4).

2.2.1 California Current Research Area

The NWFSC conducts research surveys in the CCRA, both inside and outside of the Large Marine Ecosystem (LME) boundaries (Figure 1-2). The California Current LME has a surface area of about 2.2 million km² and is bordered by the U.S. and Mexico. The California Current moves south along the western coast of North America, beginning off southern British Columbia, flowing south past Washington, Oregon and California, and ending off southern Baja California (Bograd et al. 2010). The California Current is part of the North Pacific Gyre and brings cool waters southward. Additionally, extensive upwelling of colder sub-surface waters supports large populations of whales, seabirds and important fisheries along the west coast of the U.S. (Sherman and Hempel 2009). The California Current LME includes coastal areas where NWFSC conducts research surveys for rockfish, coastal pelagics and numerous other species. However the NWFSC also conducts research that extends into deeper waters beyond the California Current LME boundary.

2.2.2 Puget Sound Research Area (PSRA)

The PSRA contains the US waters south of the US-Canada demarcation line from Cape Flattery, east through the Strait of Juan de Fuca and on to the northeasternmost part of the Strait of Georgia at the mainland border between the two nations. The research area includes all marine and estuarine waters in the US portions of Puget Sound up to mean high tide level.

2.2.3 Lower Columbia River Research Area (LCRRA).

The research area in the Lower Columbia River includes the Columbia River from Bonneville Dam to the mouth of the Columbia River west of Astoria, Oregon, including all estuarine waters up to mean high tide level. (Figure 1-4). Research efforts listed for this research area do not enter the ocean, although the mouth of the river is a dynamic process boundary that depends on tide, river flow, and physiographic variables.

3.0 SPECIES AND NUMBERS OF MARINE MAMMALS LIKELY TO BE FOUND WITHIN THE ACTIVITY AREA

Marine mammal abundance estimates in this application represent the total number of individuals that make up a given stock or the total number estimated within a particular study area. NMFS stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises that stock. For some species, this geographic area may extend beyond the U.S. EEZ. Survey abundance (as compared to stock or species abundance) is the total number of individuals estimated within the survey area, which may or may not align completely with a stock's geographic range as defined in the NMFS Stock Assessment Reports (SARs) (http://www.nmfs.noaa.gov/pr/sars/region.htm). These surveys may also extend beyond U.S. waters. Both stock abundance and survey abundance are used in this application when available to determine a density of marine mammal species within the survey area.

The species and approximate numbers of marine mammals likely to be found in the three NWFSC activity areas are shown in Table 3-1. Extralimital species are not included. These are species that do not normally occur in the survey area for which there are one or more records that are considered beyond the normal range; those species not likely to be 'taken' pursuant to the MMPA during survey operations are not included in the take request. For the three research areas where the NWFSC conducts fisheries research extralimital species include Bryde's whale (*Balaenoptera edeni*) and the North Pacific right whale (*Eubalaena japonica*).

Tables 3-1 and 3-2 list the twenty-three cetacean species (of which *Mesoplodon spp*. includes six beaked whale species) and six pinniped species that occur in the waters of the CCRA, the PSRA, and LCRRA. The list includes six cetacean species that are also listed as endangered under the ESA (southern resident killer whale, sperm whale, blue whale, fin whale, sei whale, and humpback whale), one pinniped listed as threatened under the ESA (Guadalupe fur seal) and one pinniped designated as depleted under the MMPA (Eastern Pacific stock of northern fur seal). As seen in Table 1-1, NWFSC survey activity occurs during most months of the year; trawl surveys occur primarily during May through June and September but do occur during all months, hook-and-line surveys occur during fall, and purse seine surveys occur April-October. Thus many of the marine mammal species that occur in the CCRA may be present when surveys occur. Although sea otters are found in the CCRA and PSRA, they are not included in Table 3-2. Sea otters are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) and a separate MMPA incidental take authorization application for sea otters will be sent to the USFWS. Sea otters will not be discussed further in this application.

For completeness and to avoid redundancy, the required information about all marine mammal species and numbers of species (insofar as these are known), are included in Section 4.

Table 3-1 Marine Mammal Species Encountered in the NWFSC California Current (CCRA), Puget Sound (PSRA), and Lower Columbia River (LCRRA) Research Areas.

An "X" denotes occurrence in a given research area.

Species		CCRA	PSRA	LCRRA
Common Name	**Scientific Name**			
Harbor porpoise	*Phocoena phocoena*			
--Morro Bay stock		X		
--Monterey Bay stock		X		

Species		CCRA	PSRA	LCRRA
Common Name	**Scientific Name**			
--San Francisco-Russian River stock		X		
--Northern CA/Southern OR stock		X		
--Northern OR/WA coast stock		X		X
--WA inland waters stock			X	
Dall's porpoise	*Phocoenoides dalli*	X	X	X
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	X	X	
Risso's dolphin	*Grampus griseus*	X		
Bottlenose dolphin	*Tursiops truncatus*			
--CA coastal stock		X		
--CA/OR/WA offshore stock		X		
Striped dolphin	*Stenella coeruleoalba*	X		
Short-beaked common dolphin	*Delphinus delphis*	X		
Long-beaked common dolphin	*Delphinus capensis*	X		
Northern right whale dolphin	*Lissodelphis borealis*	X		
Killer whale	*Orcinus orca*			
--Eastern North Pacific Southern Resident stock		X	X	
-- Eastern North Pacific Northern Resident stock		X		X
--Eastern North Pacific (West Coast) transient stock		X	X	X
--Eastern North Pacific offshore stock		X		
Short-finned pilot whale	*Globicephala macrorhynchus*	X		
Baird's beaked whale	*Berardius bairdii*	X		
Mesoplodont beaked whales	*Mesoplodon spp.*	X		
Cuvier's beaked whale	*Ziphius cavirostris*	X		
Pygmy or Dwarf sperm whale	*Kogia breviceps or K. sima*	X		
Sperm whale	*Physeter macrocephalus*	X		
Humpback whale	*Megaptera novaeangliae*	X	X	
Blue whale	*Balaenoptera musculus*	X		
Fin whale	*Balaenoptera physalus*	X		
Sei whale	*Balaenoptera borealis*	X		
Minke whale	*Balaenoptera acutorostrata*	X	X	
Gray whale	*Eschrichtius robustus*			

Species		CCRA	PSRA	LCRRA
Common Name	**Scientific Name**			
--Eastern North Pacific stock		X	X	
--Western North Pacific stock [1]		X		
California sea lion	*Zalophus californianus*	X	X	X
Steller sea lion (eastern stock/DPS)	*Eumetopias jubatus monteriensis*	X	X	X
Guadalupe fur seal	*Arctocephalus townsendi*	X		
Northern fur seal	*Callorhinus ursinus*			
--Eastern Pacific stock		X		
--California stock		X		
Northern elephant seal	*Mirounga angustirostris*	X		
Harbor seal	*Phoca vitulina richardsii*			
--California stock		X		
--OR/WA coast stock		X		X
--WA inland waters stocks[2]			X	

1. The western North Pacific (WNP) stock of gray whales feeds in summer and fall in the Okhotsk Sea, Russia. Historical wintering areas include waters off Korea, Japan, and China; recent tagging, photo-identification, and genetics studies found some WNP gray whales migrate to the eastern North Pacific in winter, including off Canada, the U.S., and Mexico.
2. Includes Hood Canal, Southern Puget Sound, and Washington northern inland waters stocks.

Table 3-2 Abundance and Density Estimates of Marine Mammals that Occur in the California Current[1], Puget Sound, and Lower Columbia River Research Areas

Density estimates were calculated from line-transect surveys in waters from the California/Mexican border to northern Washington and, therefore, only pertain to the CCRA. The transect lines followed a grid that was established before each survey to uniformly cover waters between the coast and approximately 556 km (300 nmi) offshore (Barlow and Forney 2007).

Common Name	Scientific Name	Federal ESA/ MMPA Status[2]	Estimated Minimum Number in the subject area[3]	Best Estimate[3]	Density/ 1000 km² (CCRA only)
CETACEANS					
Harbor porpoise	*Phocoena phocoena*	--	WA inland waters = 7,841; OR/WA coast= 15,123; Morro Bay stock = 2,102 Monterey Bay stock = 2,480 San Fran. /Russian R. = 6,625 N. CA/S. OR = 23,749	WA inland waters = 10,682; OR/WA coast =21,487; Morro Bay stock = 2,917 Monterey Bay stock = 3,715 San Fran. /Russian R. = 9,886 N. CA/S. OR = 35,769	Not determined
Dall's porpoise	*Phocoenoides dalli*	--	32,106	42,000	75.53
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	--	21,406	26,930	20.93
Risso's dolphin	*Grampus griseus*	--	4,913	6,272	10.46
Bottlenose dolphin	*Tursiops truncatus*	--	California coastal = 290; CA/OR/WA offshore = 684	California coastal = 323; CA/OR/WA offshore = 1,006	1.78
Striped dolphin	*Stenella coeruleoalba*	--	8,231	10,908	16.67
Short-beaked common dolphin	*Delphinus delphis*	--	343,990	411,211	309.35
Long-beaked common dolphin	*Delphinus capensis*	--	76,224	107,016	19.24
Northern right- whale dolphin	*Lissodelphis borealis*	--	6,019	8,334	9.75
Killer whale[4]	*Orcinus orca*	endangered -- --	Southern resident = 82 West Coast Transient = 243 Offshore = 162	Southern resident = 82 West Coast Transient = 243 Offshore = 240	0.71
Short-finned pilot whale	*Globicephala macrorhynchus*	--	465	760	0.31

Common Name	Scientific Name	Federal ESA/ MMPA Status[2]	Estimated Minimum Number in the subject area[3]	Best Estimate[3]	Density/ 1000 km^2 (CCRA only)
Baird's beaked whale	*Berardius bairdii*	--	466	847	0.88
Mesoplodont beaked whales[5]	*Mesoplodon spp.*	--	389	694	1.03
Cuvier's beaked whale	*Ziphius cavirostris*	--	4,481	6,590	3.82
Pygmy sperm whale	*Kogia breviceps*	--	271	579	1.09
Dwarf sperm whale	*Kogia sima*	--	No estimate	No estimate	1.09
Sperm whale	*Physeter macrocephalus*	endangered	1,332	2,106	1.70
Humpback whale	*Megaptera novaeangliae*	endangered	CA/OR/WA stock: 1,855 Central N.P. stock: 7,980	CA/OR/WA stock: 1,918 Central N.P. stock: 10,103	0.83
Blue whale	*Balaenoptera musculus*	endangered	1,551	1,647	1.36
Fin whale	*Balaenoptera physalus*	endangered	2,598	3,051	1.84
Sei whale	*Balaenoptera borealis*	endangered	83	126	0.09
Common Minke whale	*Balaenoptera acutorostrata scammoni*	--	202	478	0.72
Gray whale (Eastern North Pacific stock)[6]	*Eschrichtius robustus*	delisted	20,125	20,990	19.13
PINNIPEDS					
California sea lion	*Zalophus californianus*	--	153,337	296,750	Not determined
Steller sea lion eastern DPS[7]	*Eumetopias jubatus monteriensis*	delisted	34,485	63,160 - 78,198	Not determined
Guadalupe fur seal	*Arctocephalus townsendi*	threatened	3,028	7,408	Not determined
Northern fur seal	*Callorhinus ursinus*	depleted (Eastern Pacific stock only)	California = 6,722; Eastern Pacific = 541,317	California = 12,844 Eastern Pacific = 639,545	Not determined
Harbor seal	*Phoca vitulina richardsi*	--	CA stock = 27,348 OR/WA = no estimate WA Inland = no estimate	CA stock = 30,968 OR/WA unk; WA inland unk	Not determined
Northern elephant seal	*Mirounga angustirostris*	--	81,368	179,000	Not determined

1. Does not include extralimital species or sea otters.

2. Denotes ESA listing as either endangered or threatened, or MMPA listing as depleted.

3. Allen and Angliss (2015), Barlow and Forney (2007), Carretta et al. (2015), ManTech (2007), and see Section 4 below.

4. Southern Resident Killer Whales that occur in Puget Sound and other locals are listed as endangered under the ESA. All other forms of killer whale that occur in the CCRA are not listed under the ESA.

5. Six Mesoplodon spp. beaked whale species occur in the offshore waters of the California Current Research Area including Stejneger's, Hubb's, Blainville's, Perrin's, Lesser, and Gingko-toothed beaked whales.

6. The Eastern North Pacific stock of gray whales was removed from the list of threatened and endangered species in 1994; the western North Pacific stock remains endangered. Individuals from the endangered western North Pacific (WNP) stock of gray whales, which feeds in summer and fall in the Okhotsk Sea, Russia, occasionally migrate to the Eastern North Pacific (ENP) in winter. Occurrence is likely rare and extralimital.

7. A recent paper has proposed that the two Steller sea lion distinct population segments (DPS) (eastern and western) be designated as two subspecies (Phillips et al. 2009). In November 2013, NMFS issued a final rule to remove the eastern distinct population segment (DPS) of Steller sea lions from the List of Endangered and Threatened Wildlife (78 FR 66140, November 4, 2013). ; the western subspecies is listed as endangered.

4.0 STATUS, DISTRIBUTION AND SEASONAL DISTRIBUTION OF AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS

The following information summarizes data on the affected species, status and trends, distribution and habitat preferences, behavior and life history, and auditory capabilities, as available in published literature and reports, including marine mammal stock assessment reports.

Additionally, Southall et al. (2007) provided a comprehensive review of marine mammal acoustics including designating functional hearing groups. Assignment was based on behavioral psychophysics (the relationship between stimuli and responses to stimuli), evoked potential audiometry, auditory morphology, and, for pinnipeds, whether they were hearing through air or water. Since no direct measurements of hearing exist for baleen whales, hearing sensitivity was estimated from behavioral responses (or lack thereof) to sounds, commonly used vocalization frequencies, body size, ambient noise levels at common vocalization frequencies, and cochlear measurements. NOAA modified the functional hearing groups of Southall et al. (2007) to extend the upper range of low-frequency cetaceans and to divide pinnipeds into Phocids and Otariids (NOAA Fisheries 2013b). Detailed descriptions of marine mammal auditory weighting functions and functional hearing groups are available in NOAA Fisheries (2013b). Table 4-1 presents the functional hearing groups and representative species or taxonomic groups for each, although most species found in the project area are in the first two groups, low frequency cetaceans (baleen whales) and mid frequency cetaceans (odontocetes). General reviews of cetacean and pinniped sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), and Au (2000).

Table 4-1 Summary of the Five Functional Hearing Groups of Marine Mammals

Hearing groups based on Southall et al. 2007 and modified from DON 2008b and NOAA Fisheries 2013b.

Functional Hearing Group	Estimated Auditory Bandwidth	Species or Taxonomic Groups
Low Frequency Cetaceans *(Mysticetes–Baleen whales)*	7 Hz to 30 kHz (best hearing is generally below 1000 Hz, higher frequencies result from humpback whales)	All baleen whales
Mid- Frequency Cetaceans *(Odontocetes—Toothed whales)*	150 Hz to 160 kHz (best hearing is from approximately 10-120 kHz)	Includes species in the following genera: *Tursiops, Stenella, Delphinus, Lagenorhynchus, Lissodelphis, Grampus, Orcinus, Globicephala, Physeter, Ziphius, Berardius,*
High-frequency Cetaceans *(Odontocetes)*	200 Hz to 180 kHz (best hearing is from approximately 10-150kHz)	Includes species in the following genera: *Phocoena, Phocoenoides, Kogia*
Phocid pinnipeds *(true seals)*	75 Hz to 100 kHz (best hearing is from approximately 1-30 kHz)	All seals
Otariid pinnipeds *(sea lions and fur seals)*	100 Hz to 40 kHz (best hearing is from approximately 1-16 kHz)	All fur seals and sea lions

4.1 Cetaceans

As mentioned above, sea otters and extralimital species are not included. For the CCRA, PSRA, and the LCRRAs extralimital species include Bryde's whale (*Balaenoptera edeni*), the North Pacific right whale (*Balaena japonica*), and the Western North Pacific stock of gray whale (*Eschrichtius robustus)*.

4.1.1 Harbor Porpoise (*Phocoena phocoena*) Morro Bay, Monterey Bay, San Francisco-Russian River, Northern California-Southern Oregon, Northern Oregon-Washington Coast, and Washington Inland Waters Stocks

Description: Harbor porpoise are one of the smaller porpoises and have a short, stocky body. On average females reach 1.6 m in length and 60 kg while males reach 1.4 m and 50 kg (Bjørge and Tolley 2009). The body is dark gray dorsally with the chin and ventral surfaces a contrasting white that sweeps up the mid flanks (ibid). They have a small triangular dorsal fin that facilitates recognition when swimming but are also known to lie on the surface (ibid). Harbor porpoise tend to avoid ships and rarely bow ride.

Status and trends: Harbor porpoise belong to the Order Cetacea, Suborder Odontoceti, and Family Phocoenidae. Six stocks of harbor porpoise are recognized within the NWFSC research areas: Morro Bay, Monterey Bay, San Francisco-Russian River, Northern California-Southern Oregon, and Northern Oregon/Washington coastal stocks in the CCRA, and Washington inland waters stock in the PSRA. Harbor porpoise are not listed as "threatened" or "endangered" under the ESA or as "depleted" under the MMPA. In the following stock sections we provide information for fisheries related mortality; other mortality types have generally not been reported (Carretta et al. 2014) for harbor porpoise within the NWFSC research area with the exception of the Northern Oregon/Washington Coast stock.

<u>Morro Bay stock</u>: The estimated abundance of the Morro Bay stock, based on aerial surveys in 2012, is 2,917 animals. The minimum population estimate is 2,102 and the PBR is 21 animals (Carretta et al. 2014). There was one fishery-related mortality reported within this stock's range, for an annual average of ≥0.2 for 2007 to 2011 (Carretta et al. 2014).

<u>Monterey Bay stock</u>: The estimated abundance of the Monterey Bay stock, based on aerial surveys in 2011, is 3,715 animals. The minimum population estimate is 2,480 and the PBR is 25 animals (Carretta et al. 2014). There was no documented fishery-related mortality or injury within this stock's range from 2007 to 2011 (Carretta et al. 2014).

<u>San Francisco-Russian River stock:</u> The estimated abundance of the San Francisco-Russian River stock, based on aerial surveys in 2007-2011, is 9,886 animals (Carretta et al. 2014). The minimum population estimate is 6,625 animals and the PBR is 66 animals. No fishery-related takes or strandings were reported between 2007 and 2011 (Carretta et al. 2014).

<u>Northern California-Southern Oregon stock:</u> The estimated abundance of the Northern California-Southern Oregon stock, based on aerial surveys in 2007-2011, is 35,769 harbor porpoises (Carretta et al. 2014). The minimum population estimate is 23,749 animals and the PBR is 475 animals. Stranding data from 2007 indicate interactions with entangling net fisheries for an estimated level of known human-caused mortality and serious injury of ≥0.6 harbor porpoises per year (Carretta et al. 2014).

Because the northern boundary of this stock has changed two times in recent years, trends in abundance have been examined only for the northern California portion of this stock. A possible increasing trend in abundance is apparent from surveys conducted between 1989 and 2007, but the trend is not statistically significant (Carretta et al. 2014).

<u>Northern Oregon/Washington coastal stock:</u> The most recent surveys from which estimates were derived for the Northern Oregon/Washington coastal stock of harbor porpoises were in 2010-2011. Adjusted for groups missed by aerial observers, the corrected estimate of abundance for harbor porpoise in the coastal waters of northern Oregon (north of Lincoln City) and Washington is 21,487 (Carretta et al. 2014). The

minimum population estimate is 15,123 animals and the PBR is 151 animals. Stranding data from 2007-2011 indicate interactions with entangling net fisheries for an estimated minimum level of known fishery-related mortality of ≥3.0 harbor porpoises per year and a total of 114 harbors porpoise strandings reported as part of an Unusual Mortality Event (UME) whose cause has not been determined (Carretta et al. 2014).

Washington inland waters stock: As summarized in Carretta et al. (2013, and citations therein), aerial surveys of the inside waters of Washington and southern British Columbia were conducted during August of 2002 and 2003. These aerial surveys included the Strait of Juan de Fuca, San Juan Islands, Gulf Islands, and Strait of Georgia, which includes waters inhabited by the Washington Inland Waters stock of harbor porpoise as well as harbor porpoise from British Columbia. The corrected estimated abundance for the Washington Inland Waters stock of harbor porpoise in 2002/2003 is 10,682 (CV=0.38) animals. Since this abundance estimate is >8 years old, minimum population size, trends, and PBR cannot be determined for this stock. The minimum total fishery mortality and serious injury for this stock is ≥2.2 harbor porpoise per year, based on self-reported fisheries and strandings (Carretta et al. 2014).

Distribution and habitat preferences: Harbor porpoises are distributed throughout the coastal waters of the North Pacific, North Atlantic, and Black Sea. In the eastern North Pacific they occur from Point Conception, California to Alaska and across to Russia (Carretta et al. 2013). Harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved. Recent preliminary genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range. They are typically found in small groups of 1-3 individuals often consisting of a female-calf pair, but larger groups are not uncommon (Bjørge and Tolley 2009). The species frequents inshore areas, shallow bays, estuaries, and harbors. Harbor porpoises are found almost exclusively shoreward of the 200 m contour line, with the vast majority found inside the 50 m curve (Gearin and Scordino 1995; Osmek et al. 1996). A radio-tagged animal remained over deep water of the southern Strait of Georgia (200 m) and movements were confined to a 65 square kilometer area of the capture site off Orcas Island, Washington (Hanson et al. 1999).

Behavior and life history: Harbor porpoises calve and breed throughout the range, and they generally give birth in summer from May through July. Calves remain dependent for at least six months (Leatherwood et al. 1982). Harbor porpoise are usually shy and avoid vessels; thus, they are difficult to approach. Harbor porpoise often feed near bottom in waters less than 200 m deep on bottom-dwelling fishes and small pelagic schooling fishes with high lipid content; herring and anchovy are common prey (Bjørge and Tolley 2009; Leatherwood and Reeves 1986).

Acoustics and hearing: The harbor porpoise has the highest upper-frequency limit of all odontocetes investigated. Kastelein et al. (2002) found that the range of best hearing was from 16 to 140 kHz, with a reduced sensitivity around 64 kHz. Maximum sensitivity (about 33 dB re 1 μPa) occurred between 100 and 140 kHz. This maximum sensitivity range corresponds with the peak frequency of echolocation pulses produced by harbor porpoises (120–130 kHz). Harbor porpoise are in the high-frequency functional hearing group, whose estimated auditory bandwidth is 200 Hz to 180 kHz (Southall et al. 2007). Their vocalizations range from 110 to 150 kHz (DON 2008a) (Table 4-1).

4.1.2 Dall's Porpoise (*Phocoenoides dalli*) California, Oregon, Washington Stock

Description: Dall's porpoises are a stocky, medium sized porpoise with a wide-based dorsal fin that is topped with white pigment. The tail stock is deepened and there is a noticeable beak; the flippers and fluke are small (Jefferson 2009a). Males are somewhat larger than females but both may reach a length of about 2.2 m and weigh about 150 kg or more. The body is black with a large white flank patch that extends to the level of the dorsal fin. They are extremely fast in the water and are often misidentified as 'baby killer whales' (Osborne et al. 1988).

Status and trends: Dall's porpoise belong to the Order Cetacea, Suborder Odontoceti, and Family Phocoenidae. Up to ten populations or stocks are recognized, one of which is the California/Oregon/Washington stock. An estimated 42,000 Dall's porpoises were estimated in the California, Oregon, and Washington population (Carretta et al. 2014). The minimum population estimate is 32,106 Dall's porpoise with a PBR of 257 animals. They were the most common small cetacean observed in ship surveys off the Washington coast from 1995 to 2002 with 115 sightings of 406 animals and mean group size of 3.6 animals (Barlow and Forney 2007). Additional numbers of Dall's porpoise occur in the inland waters of Washington state, but the most recent abundance estimate obtained in 1996 (900 animals, CV = 0.40) is over 8 years old and is not included in the overall estimate of abundance for this stock. Barlow and Forney (2007) estimated the density of Dall's porpoise at 75.53 porpoise/1000 km^2.

As summarized in Carretta et al. (2014, and citations therein) the status of Dall's porpoise in California, Oregon and Washington relative to the Optimal Sustainable Population (OSP) is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2002-2006 (1.6 animals) is estimated to be less than the PBR (257), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: The species is found only in temperate waters of the North Pacific and adjacent seas (Jefferson 2009a). The southern end of this population's range is not well-documented, but they are commonly seen off Southern California in winter, and during cold-water periods they probably range into Mexican waters off northern Baja California. Dall's porpoises occur in small groups, although aggregations of at least 200 individuals have been reported. Dall's porpoise occur only rarely in groups of mixed species, although they are sometimes seen in the company of harbor porpoises and gray whales (Jefferson 2009a). It is probably the most widely distributed cetacean in temperate and subarctic regions of the North Pacific and Bering Sea. This is an oceanic species found along the continental shelf and in inland and coastal waters. There are seasonal inshore-offshore and north-south movements, but these movements are poorly understood (Jefferson 2009a). Hanson (2007) described movements of radio-tagged Dall's porpoise from the San Juan Islands to the outer coast coincident with the timing of development of the Juan de Fuca eddy in two consecutive years. Their departure is consistent with the breakdown of this feature.

Behavior and life history: Calves are born in summer, and gestation is thought to be about one year (Osborne et al. 1988; Jefferson 2009a). Dall's porpoises apparently feed at night. Prey species in the inland waters of British Columbia and Puget Sound include squids and schooling fishes (Walker et al. 1998). Dall's porpoise equipped with dive recorders dove to about 94 m in water that exceeded 200 m while feeding in Puget Sound inland waters. Dive duration was about 1.3 minutes (Baird and Hanson 1996).

Acoustics and hearing: Only short duration pulsed sounds have been recorded for Dall's porpoise; this species apparently does not whistle often (Richardson et al. 1995). Dall's porpoises produce short-duration (50 to 1,500 μs), high-frequency, narrow band clicks, with peak energies between 120 and 160 kHz. There are no published data on hearing ability of this species (DON 2008b).

4.1.3 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*) California, Oregon, Washington Northern and Southern Stocks

Description: Pacific white-sided dolphins are a medium sized dolphin with adults ranging from 1.7 m to 2.5 m in length and weighing 75-198 kg; males are slightly larger than females (Black 2009). They are boldly marked with a dark gray or black dorsal surface, light gray sides and light gray 'suspender stripes' anterior. The dorsal fin is falcate to lobate with a rounded tip; it has a darker leading edge with light gray color covering two thirds of the posterior portion; the flukes are all dark (Black 2009). A few predominately white individuals with small patches of black pigmentation on the sides, heads, and fins have been identified in Monterey Bay.

Status and trends: Pacific white-sided dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Although there is clear evidence that two forms of Pacific white-sided dolphins occur along the U.S. west coast, there are no known differences in color pattern, and it is not currently possible to distinguish animals without genetic or morphometric analyses. Geographic stock boundaries appear dynamic and are poorly understood, and therefore cannot be used to differentiate the two forms.

Pacific white-sided dolphins may spend time outside the U.S. Exclusive Economic Zone (EEZ), and therefore a multi-year average abundance estimate including California, Oregon and Washington is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimates for California, Oregon and Washington waters based on the two most recent ship surveys is 26,930 with a minimal population estimate of 21,406 dolphins. Barlow and Forney (2007) estimated the density of Pacific white-sided dolphins at 20.93 dolphins/1000 km^2. The PBR is 171 animals. No long-term trends in the abundance of Pacific white-sided dolphins in California, Oregon and Washington are suggested based on historical and recent surveys (Carretta et al. 2014).

As summarized in Carretta et al. (2011, and citations therein), the status of Pacific white-sided dolphins in California, Oregon and Washington relative to OSP is not known, and there is no indication of a trend in abundance for this stock. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality of 17.8 dolphins during 2007-2001 includes commercial fishery (11.8/yr) and research-related mortality (6.0/yr). Thus is estimated to be less than the PBR (171), and, therefore, they are not classified as a “strategic" stock under the MMPA. The total commercial fishery mortality and serious injury (11.8/yr) for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. Including research-related takes, annual mortality of this stock (17.8/yr) exceeds 10% of the calculated PBR, but under Section 118 of the MMPA, only commercial takes are evaluated against the zero mortality rate goal (ZMRG) (Carretta et al. 2014).

Distribution and habitat preferences: This dolphin is one of the most abundant pelagic species of dolphin found in cold-temperate North Pacific waters. In the eastern Pacific it occurs as far west as Amchitka Island in the central Aleutian Islands through the Gulf of Alaska and down to 20^o N, just south of Baja California (Black 2009). They do not migrate but exhibit seasonal shifts in distribution related to oceanographic variability. As summarized in Carretta et al. (2014, and citations therein), Pacific white-sided dolphins are endemic to temperate waters of the North Pacific Ocean, and are common both on the high seas and along the continental margins. Off the U.S. west coast, Pacific white-sided dolphins have been seen primarily in shelf and slope waters. Sighting patterns from recent aerial and shipboard surveys conducted in California, Oregon and Washington suggest seasonal north-south movements, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase in late spring and summer. They typically inhabit productive continental shelf and slope waters generally within 185 km of shore (Black 2009). They frequent some areas with complex bathymetry such as Monterey Bay, CA, an area where deep submarine canyons approach shore (ibid).

Behavior and life history: As summarized from Black (2009, and citations therein) calving occurs from May to September. Age and length of maturation varies by area with females becoming sexually mature at 8-11 years with a 4 to 5-year calving interval. These are highly social dolphins and are avid bow riders that commonly occur in groups of less than a hundred but can form herds of over a thousand animals. They often associate with other dolphins typically Risso’s, commons, and northern right-whale dolphins and porpoises and occasionally feed near humpback whales. Killer whales (*Orcinus orca*) appear to be a significant predator. Prey species include cephalopods (30 species known to be consumed) and schooling fishes (at least 60 species) (Black 2009). Pacific white-sided dolphins equipped with radio transmitters had mean dive duration of 24 seconds and a maximum dive time of 6.2 minutes (ibid).

Acoustics and hearing: As summarized in DON (2008b, and citations therein), vocalizations produced by Pacific white-sided dolphins include whistles and clicks. Whistles are in the frequency range of 2 to 20 Hz. Peak frequencies of the pulse trains for echolocation fall between 50 and 80 kHz; the peak amplitude is 170 dB re 1µPa-m. Underwater hearing sensitivity of the Pacific white-sided dolphin is from 75 Hz through 150 kHz. The greatest sensitivities were from 4 to 128 kHz. Below 8 Hz and above 100 kHz, this dolphin's hearing was similar to that of other toothed whales.

4.1.4 Risso's Dolphin (*Grampus griseus*) California, Oregon, Washington Stock

Description: Risso's dolphins are large dolphins with adults of both sexes reaching up to 4 m in length; there is no evidence of sexual dimorphism (Baird 2009). The anterior body is robust tapering to a relatively narrow tail stock with a relatively small dorsal fin. The bulbous head has a distinct vertical crease along the anterior surface of the melon (Baird 2009). Color patterns change with age; older animals are covered with linear scars and may appear whitish on the dorsal and lateral surfaces. The dorsal fin is falcate and black in color (Baird 2009). They are often confused with killer whales due to the large size of their dorsal fin.

Status and trends: Risso's dolphins belong to the Order Cetacea, Suborder Odontoceti, and are the fifth largest member of the Family Delphinidae. As oceanographic conditions vary, Risso's dolphins may spend time outside the U.S. EEZ, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the two most recent ship surveys is 6,272 animals with a minimum population estimate of 4,913; the PBR for Risso's dolphins is 39 animals. Barlow and Forney (2007) estimated the density of Risso's dolphins at 10.46 dolphins/1000 km^2. There is no apparent trend in abundance between the most recent survey years 1991 and 2008 (Carretta et al. 2014).

As summarized in Carretta et al. (2014, and citations therein) the status of Risso's dolphins off California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the ESA nor as "depleted" under the MMPA. The average annual human-caused (fishery-related) mortality was 1.6 dolphins for the period of 2004 to 2008; this is well below the PBR (39), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: Risso's dolphins are distributed world-wide in tropical and warm-temperate waters. Off the U.S. west coast, Risso's dolphins are commonly seen on the shelf in the Southern California Bight and in slope and offshore waters of California, Oregon and Washington (Carretta et al. 2013). Animals found off California during the colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer. Risso's dolphins were acoustically detected off the outer coast of Washington an average of five to six days per year, but were only visually observed on two occasions (Oleson et al. 2009). The southern end of this population's range is not well-documented, but previous surveys have shown a conspicuous 500 nm distributional gap between these animals and Risso's dolphins sighted south of Baja California and in the Gulf of California. Thus this population appears distinct from animals found in the eastern tropical Pacific and the Gulf of California (Carretta et al. 2013). They seem to prefer temperate and tropical waters in steep edged habitat between 400- and 1000-m deep. In the North Pacific they can be found as far north as the Gulf of Alaska and the Kamchatka Peninsula and south to Tierra del Fuego and New Zealand (Baird 2009).

Behavior and life history: As summarized in Baird (2009, and citations therein), Risso's dolphins are relatively gregarious, typically travelling in groups of 10-50 individuals; the largest group reported had over 4,000 individuals. They have been observed bow riding in front of gray whales and are often seen surfing in swells. Gestation is 13-14 months and calving intervals are about 2.4 years with peak calving during winter in the eastern North Pacific. Sexual maturity for females is thought to be 8-10 years of age and males 10-12 years of age. They feed almost exclusively on squids, likely at night (Baird 2009).

Acoustics and hearing: Risso's dolphins are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations of Risso's dolphin range from 400 Hz to 65 Hz (DON 2008a) (Table 4-1).

4.1.5 Bottlenose Dolphin (*Tursiops truncatus*) California Coastal Stock and Offshore Stock

Description: Bottlenose dolphins are large and robust, varying in color from light gray to charcoal. The common bottlenose dolphin is characterized by a medium-length stocky beak that is clearly distinct from the melon (Jefferson et al. 2008). The dorsal fin is tall and falcate. There are striking regional variations in body size, with adult lengths from 1.9 to 3.8 m (Wells and Scott 2009).

Status and trends: Bottlenose dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Two forms of common bottlenose dolphins are recognized in the western North Pacific Ocean: California coastal stock (coastal) and California/Oregon/Washington offshore (offshore) stock. As summarized in Carretta et al. (2014, and citations therein) the population of the coastal stock has been estimated based on photographic mark-recapture surveys conducted along the San Diego coast in 2004 and 2005. The most recent estimate of population size is 323 dolphins but may be closer to 450-500 animals, with a minimum population estimate of 290 animals and a PBR of 2.4 dolphins per year. The population has remained stable for about 20 years.

Because the distribution of the offshore stock of bottlenose dolphins appears to vary inter-annually and they may spend time outside the U.S. EEZ, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most comprehensive estimate for California, Oregon and Washington waters based on the 2005 and 2008 ship surveys, is 1,006 offshore bottlenose dolphins with a minimum population estimate of 684; the PBR is 5.5 animals per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of bottlenose dolphins at 1.78 dolphins/1000 km^2.

The status of coastal and offshore bottlenose dolphins relative to OSP is not known, and there is no evidence of a trend in abundance. They are not listed as "threatened" or "endangered" under the ESA nor as "depleted" under the MMPA. Coastal and offshore bottlenose dolphins are not classified as a "strategic" stock under the MMPA because total annual fishery mortality and serious injury for this stock ($\geq$ 0.2 per year) is less than the PBR (2.4 and 5.5, respectively). The total human-caused mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: In general, bottlenose dolphins are distributed world-wide; in the North Pacific they are commonly found as far north as the southern Okhotsk Sea, Kuril Islands, and central California. Bottlenose dolphins are distributed in tropical and warm-temperate waters that range from about 10 to 32^{o} C. They inhabit temperate and tropical shorelines, adapting to a variety of marine and estuarine habitats, even ranging into rivers (Wells and Scott 2009). They are primarily coastal but do occur in pelagic waters, near oceanic islands and over the continental shelf. In many regions, including California, separate coastal and offshore populations exist. As summarized in Carretta et al. (2014, and citations therein), California coastal bottlenose dolphins are found within about one kilometer of shore primarily from Point Conception (but as far north as San Francisco) south into Mexican waters, at least as far south as San Quintin, Mexico. In southern California, animals are found within 500 m of the shoreline 99% of the time and within 250 m 90% of the time. Oceanographic events appear to influence the distribution of animals along the coasts of California and Baja California as indicated by a change in residency patterns along Southern California and a northward range extension into central California after the 1982-83 El Niño is known.

Offshore bottlenose dolphins have been found at distances greater than a few kilometers from the mainland and throughout the Southern California Bight. They have also been documented in offshore waters as far north as 41^{o} N, and they may range into Oregon and Washington waters during warm water periods. Sighting records off California and Baja California suggest that offshore bottlenose dolphins have a continuous distribution in these two regions. Based on aerial surveys and shipboard surveys no seasonality in distribution is apparent. Offshore bottlenose dolphins are not restricted to U.S. waters, but cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries that may take this species (e.g., gillnet fisheries).

Behavior and life history: Births have been reported from all seasons with peaks during spring-summer months. Females may give birth as late as their 48th year. A large variety of fishes and squids forms most of the diet and varies by region, although they do seem to prefer sciaenids (drums and croakers), scombrids (mackerels and tunas), and mugilids (mullets) (Wells and Scott 2009). Most consumed fish are bottom dwellers. Sharks are probably the most important predators on bottlenose dolphins. As summarized in DON (2008a, and citations therein), dive durations as long as 15 min are recorded for trained individuals but typical dives are more shallow and of a much shorter duration. Mean dive durations of Atlantic bottlenose dolphins typically range from 20 to 40 seconds at shallow depths and can last longer than 5 minutes during deep offshore dives. Offshore bottlenose dolphins regularly dive to 450 m and possibly as deep as 700 m.

Acoustics and hearing: Coastal and offshore stocks of bottlenose dolphins are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Bottlenose dolphin vocalization frequencies range from 3.4 to 130 kHz (DON 2008a) (Table 4-1).

4.1.6 Striped Dolphin (*Stenella coeruleoalba*) California, Oregon, Washington Stock

Description: The striped dolphin is uniquely marked with black lateral stripes from eye to flipper and eye to anus. There is also a white V-shaped “spinal blaze” originating above and behind the eye and narrowing to a point below and behind the dorsal fin (Archer 2009). There is a dark cape and white belly; the lateral field is usually darker than the ventral. This is a relatively robust dolphin with a long, slender beak and prominent dorsal fin. The longest specimen was 2.56 m and the heaviest was 156 kg but mean maximum body length in the western pacific is 2.4 m for males and 2.2 m for females (Archer 2009).

Status and trends: Striped dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The abundance of striped dolphins in this region appears to be variable between years and may be affected by oceanographic conditions. Because animals may spend time outside the U.S. EEZ as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the 2005 and 2008 ship surveys is 10,908 striped dolphins; the minimum population estimate is 8,231 striped dolphins with a PBR of 82 striped dolphins per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of striped dolphins at 16.67 dolphins/1000 km^2.

The status of striped dolphins in California relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality for 2004-2008 of 0.2 dolphins is based on a single stranding of a striped dolphin with evidence of possible impact or fisheries interaction. There were no directly observed incidental takes during this time period (Carretta et al. 2014). Because recent fishery and human-caused mortality is less than 10% of the PBR (82), striped dolphins are not classified as a "strategic" stock under the MMPA, and the total fishery mortality and serious injury for this stock can be considered to be insignificant and approaching zero.

Distribution and habitat preferences: Striped dolphins are distributed worldwide in cool-temperate to tropical zones. On recent surveys extending about 300 nm offshore of California, they were sighted within about 100-300 nm from the coast. No sightings have been reported for Oregon and Washington waters, but striped dolphins have stranded in both states. Striped dolphins are also commonly found in the central North Pacific, but sampling between this region and California has been insufficient to determine whether the distribution is continuous. Based on sighting records off California and Mexico, striped dolphins appear to have a continuous distribution in offshore waters of these two regions (Carretta et al. 2013). Striped dolphins are usually found beyond the continental shelf, typically over the continental slope out to oceanic waters and are often associated with convergence zones and waters influenced by upwelling. The species feeds on a variety of pelagic and benthopelagic fishes and squids.

Behavior and life history: As summarized from Archer (2009, and references therein), mating is seasonal and gestation lasts 12-13 months. Females become sexually mature between 5 and 13 years of age and between 7 and 15 years of age for males. Striped dolphins are acrobatic and perform a variety of aerial behaviors but they do not commonly bow ride. They often feed in pelagic or benthopelagic zones along the continental slope or just beyond it in oceanic waters. A majority of their prey possesses luminescent organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 200 to 700 m to reach potential prey. Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements (Archer 2009).

Acoustics and hearing: Striped dolphins are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Their vocalizations range from 6 to > 24 kHz (DON 2008a) (Table 4-1).

4.1.7 Short-Beaked Common Dolphin (*Delphinus delphis*) California, Oregon, Washington Stock

Description: As summarized in DON (2008a, and citations therein) and Perrin (2009), short-beaked common dolphins are slender, moderately robust dolphins, with a moderate length beak, and a tall, slightly falcate dorsal fin. The beak is shorter than in long-beaked common dolphins, and the melon rises from the beak at a steeper angle. Short-beaked common dolphins are distinctively marked with a V-shaped saddle caused by a dip in the cape below the dorsal fin, yielding an hourglass pattern on the side of the body. The back is dark brownish-gray, the belly is white, and the anterior flank patch is tan to cream in color. The lips are dark, and there is a dark stripe from the eye to the apex of the melon and another one from the chin to the flipper (the latter is diagnostic to the genus). There are often variable light patches on the flippers and dorsal fin. Length ranges up to about 2.3 m (females) and 2.6 m (males).

Status and trends: Short-beaked common dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. As summarized in Carretta et al. (2014, and citations therein), the most recent estimates of abundance estimates are based on two summer/fall shipboard surveys that were conducted within 300 nm of the coasts of California, Oregon and Washington in 2005 and 2008. The distribution of short-beaked common dolphins throughout this region is highly variable, apparently in response to oceanographic changes on both seasonal and inter-annual time scales. As oceanographic conditions vary, short-beaked common dolphins may spend time outside the U.S. EEZ, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimates for California, Oregon and Washington waters based on the two ship surveys is 411,211 short-beaked common dolphins; the minimum population estimate is 343,990 short-beaked common dolphins with a PBR of 3,440 short-beaked common dolphins per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of short-beaked common dolphins at 309.35 dolphins/1000 km^2.

The status of short-beaked common dolphins in Californian waters relative to OSP is not known (Carretta et al. 2014). The observed increase in abundance of this species off California probably reflects a distributional shift, rather than an overall population increase due to growth. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2002-2006 is estimated to be less than the PBR (3,440), and therefore they are not classified as a "strategic" stock under the MMPA. The total estimated fishery mortality and injury for short-beaked common dolphins is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: Short-beaked common dolphins are the most abundant dolphin in offshore warm-temperate waters in the Atlantic and Pacific (Perrin 2009). They occur worldwide from about 40-60° N to about 50° S (Perrin 2009). They are the most abundant cetacean off California, and are widely distributed between the coast and at least 300 nm distance from shore (Carretta et al. 2014). The abundance of this species off California has been shown to change on both seasonal and inter-annual time scales. Historically, they were reported primarily south of Pt. Conception, but have been commonly recorded as far north as 42° N (Carretta et al. 2014). The short-beaked common dolphin is found in coastal and offshore waters along the eastern Pacific coast from Peru to Vancouver Island. They are widely distributed to 556 km offshore (Carretta et al. 2014). They tend to prefer cooler water farther offshore than the sympatric long-beaked common dolphin; they occupy upwelling-modified habitats with less tropical characteristics than surrounding water masses (Perrin 2009). During summer and fall, short-beaked common dolphins primarily occur along the outer coast in waters deeper than 200 m, south of 42° N and to a lesser extent in water depths between 100 m and 200 m south of 42° N, and seaward of the 100 m water depth north of 42° N. In winter and spring, animals typically stay south of the 13° C isotherm. There is a rare occurrence for this species in waters cooler than 12° C and within the Puget Sound (DON 2008b). Separate northern, central, and southern stocks associated with different upwelling areas are recognized in the management of incidental mortality in tuna fisheries (Perrin 2009).

Behavior and life history: Short-beaked common dolphins are usually found in large groups of hundreds to thousands of individuals and are often associated with other marine mammal species. Gestation is 10-11.7 months with a calving interval of 1-3 years, depending on location (Perrin 2009). Age at sexual maturity varies by region from 3 years to 7-12 years for males and 2-4 and 6-8 years for females. Cooler water populations exhibit more seasonality in reproduction (Perrin 2009). There are limited direct measurements of dive behavior but dives to > 656 ft (200 m) are possible, but most occur in the range of 9-50 m based on a study on one tagged individual tracked off San Diego (DON 2008b). Diel fluctuations in vocal activity of this species (more vocal activity during late evening and early morning) appear to be linked to feeding on the deep scattering layer as it rises. Foraging dives up to 200 m in depth have been recorded off southern California (DON 2008b).

Acoustics and hearing: As summarized in DON (2008a, and citations therein), recorded vocalizations include whistles, chirps, barks, and clicks. Clicks range from 0.2 to 150 kHz with dominant frequencies between 23 and 67 kHz and estimated source levels of 170 dB re 1 μPa. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 18 kHz. Maximum source levels are approximately 180 dB 1 μPa-m.

4.1.8 Long-Beaked Common Dolphin (*Delphinus capensis*) California Stock

Description: As summarized in Perrin (2009), all common dolphins are slender and have a moderate length beak, and a tall, slightly falcate dorsal fin that may tend toward triangular. The beak is longer than in short-beaked common dolphins, and the melon rises from the beak at a steeper angle. Long-beaked common dolphins in California tend to be longer and heavier than the short-beaked common dolphin. Both species are distinctively marked with a V-shaped saddle caused by a dip in the cape below the dorsal fin, yielding an hourglass pattern on the side of the body. The back is dark brownish-gray, the belly is white, and the anterior flank patch is tan to cream in color. The lips are dark, and there is a dark stripe from the eye to the apex of the melon and another one from the chin to the flipper (the latter is diagnostic to the genus). There are often variable light patches on the flippers and dorsal fin. Length ranges up to about 2.3 m (females) and 2.6 m (males).

Status and trends: Long-beaked common dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Long-beaked common dolphins have only recently been recognized as a distinct species. Along the U.S. west coast, their distribution overlaps with that of the short-beaked common dolphin, and much historical information has not distinguished between these two species. The most recent geometric mean abundance estimate is 107,016 long-beaked common dolphin based on 2008 and 2009 ship line transect surveys of California, Oregon, and Washington waters with a minimum population estimate of 76,224; the PBR is 610 long-beaked common dolphins for the California stock (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of long-beaked common dolphins at 19.24 dolphins/1000 km^2.

The status of long-beaked common dolphins in California waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA or as “depleted” under the MMPA. Average annual human-caused mortality and serious injury is 13.8. This includes 13.0 dolphins per year in commercial fisheries (2006-2010) and a 2007-2011 average annual mortality (0.8 dolphins) resulting from a single blast trauma event associated with underwater detonations by the U.S. Navy near San Diego in 2011 (Carretta et al. 2014). The average annual human-caused mortality from 2006-2011 does not exceed the PBR (610), and therefore they are not classified as a "strategic" stock under the MMPA. The average total fishery mortality and injury for long-beaked common dolphins (13) is less than 10% of the PBR and, therefore, is considered to be insignificant and approaching zero mortality and serious injury rate (Carretta et al. 2014).

Distribution and habitat preferences: Long-beaked common dolphins are commonly found within about 50 nm of the coast, from Baja California (including the Gulf of California) northward to about central California. California waters represent the northern limit for this stock and they likely move between U.S. and Mexican waters. No information on trends in abundance is available for this stock because of high interannual variability in line-transect abundance estimates. Heyning and Perrin (1994) detected changes in the proportion of short-beaked to long-beaked common dolphins stranding along the California coast, with the short-beaked common dolphin stranding more frequently prior to the 1982-83 El Niño (which increased water temperatures off California), and the long-beaked common dolphin more commonly observed for several years afterwards. Thus, it appears that both relative and absolute abundance of these species off California may change with varying oceanographic conditions (Carretta et al. 2014). The long-beaked species seems to prefer shallower and warmer water and generally occurs closer to shore than the short-beaked form (Perrin 2009).

Behavior and life history: Long-beaked common dolphins, as with the short-beaked, are usually found in large groups of hundreds to thousands of individuals and are often associated with other marine mammal species. Other traits are as described above for the short-beaked common dolphin.

Acoustics and hearing: Long-beaked common dolphins likely have similar acoustics and hearing to the short-beaked common dolphin. As above for the short-beaked common dolphin, DON (2008a) state that recorded vocalizations include whistles, chirps, barks, and clicks. Clicks range from 0.2 to 150 kHz with dominant frequencies between 23 and 67 kHz and estimated source levels of 170 dB re 1 μPa. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 18 kHz. Maximum source levels are approximately 180 dB 1 μPa-m.

4.1.9 Northern Right-Whale Dolphin (*Lissodelphis borealis*) California, Oregon, Washington Stock

Description: Right-whale dolphins, of which there are two recognized species, are slender, sleek dolphins known for their distinctive black and white color patterns and lack of a dorsal fin. The northern right-whale dolphin is mainly black with a white ventral patch that runs from the fluke notch to the throat region; there is another white patch on the ventral tip of the rostrum and the underside of the flipper (Lipsky 2009). They can grow to 3 m in length and 116 kg; and males tend to be larger than females.

Status and trends: Northern right-whale dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. A multi-year average abundance estimate is the most appropriate for management within U.S. waters; the 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the two ship surveys is 8,334 (CV= 0.40) northern right-whale dolphins with a minimum population estimate for 2005-2008 of 6,019 dolphins; the PBR is 48 dolphins per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of northern right-whale dolphins at 9.75 dolphins/1000 km^2.

The status of northern right-whale dolphins in California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality of northern right whale dolphins is 4.8 (3.6 commercial fishery-related, 1.2 research-related) for 2004 to 2008. This is well below PBR and total fishery mortality and serious injury for this stock does not exceed 10% of the calculated PBR, so can be considered to be approaching zero mortality and serious injury rate (Carretta et al. 2014). The average annual human-caused mortality in 2002-2006 (4.8 animals) is estimated to be less than the PBR (48), and therefore they are not classified as a "strategic" stock under the MMPA.

Distribution and habitat preferences: This species is endemic to the North Pacific Ocean, and is found primarily in cool-temperate (8–19^{o} C) continental shelf and slope waters. They range from the Kuril Islands south to Sanriko, Japan extending eastward to the Gulf of Alaska and south to Southern California (Lipsky 2009). Northern right-whale dolphins occur in the survey area year-round, but their abundance and distribution vary seasonally. This species is most abundant off central and northern California in nearshore waters in winter. They occur off Oregon and Washington except in winter; peak abundance occurs along the continental slope in fall (Carretta et al. 2014; DON 2008b). Right-whale dolphins prefer cool-temperate and subarctic waters in the North Pacific. They tend to be offshore oceanic cetaceans with rare inshore sightings (Lipsky 2009).

Behavior and life history: Sexual maturity occurs at about 10 years of age. Although calving seasonality is unknown, small calves are seen in winter and early spring. They tend to be gregarious and travel in groups of up to 2,000-3,000 in the North Pacific. Males may attain sexual maturity between 212 and 220 cm in length and females at about 200 cm but few data are available on age, growth, and reproduction. The diet primarily includes squids and mesopelagic fishes. No dive data are available.

Acoustics and hearing: As summarized in DON (2008b), clicks with high repetition rates and whistles have been recorded from animals at sea. Maximum source levels were approximately 170 dB 1 µPa-m. Mean frequency of individual echolocation clicks was 31.3 kHz (range of 23 – 41 kHz; SD = 3.7 kHz). There is no published data on the hearing abilities of this species.

4.1.10 Killer Whale (*Orcinus orca*) – Resident Ecotype

Description: Killer whales are the largest member of the dolphin family attaining maximum body lengths of 9 m for males and 7.7 m for females (Ford 2009). Maximum measured weights for males is 5,568 kg and for females 3,810 kg (Ford 2009). Males develop larger appendages than females including the pectoral fins, tail flukes, and dorsal fin, which is erect in shape and may be as high as 1.8 m in males.

Directly behind the dorsal fin is a gray area of variable shape called the saddle patch. Killer whales are generally black dorsally and white ventrally with a conspicuous elliptically shaped white patch behind the eye (post-ocular patch). Considerable variation exists in the shape and color of the post-ocular patch, saddle patch, and the size and shape of the dorsal fin such that they are used to identify individuals.

Status and trends: Killer whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. There are three recognized ecotypes in the North Pacific Ocean: residents, transients, and offshores (Bigg et al. 1990; Ford et al. 2000; Krahn et al. 2004). Resident killer whales forage primarily for fish in relatively large groups in coastal areas. Transient killer whales, whose range extends over a broader area, primarily hunt marine mammals (Krahn et al. 2004; Baird et al. 1992). Transient pods are usually fewer in number than resident pods, and they typically have different dorsal fin shapes and saddle patch pigmentation than resident pods. Little is known about offshore killer whales, but their groupings are large, they range from Mexico to Alaska, and their prey includes fish, though they have been documented feeding on sharks (Dahlheim et al. 2008; Ford et al. 2000; Ford et al. 2011; Krahn et al. 2004).

In 2005, NMFS listed the Puget Sound southern resident killer whale (SRKW) distinct population segment (DPS) as an endangered species under the ESA. Listing factors included reduced quantity and quality of prey, persistent pollutants that could cause immune or reproductive system dysfunction (see Krahn et al. 2009), oil spills, and noise and disturbance from vessel traffic. Additionally, the small size of this stock made it potentially vulnerable to inbreeding that could cause a major population decline. In June 2006, NMFS designated critical habitat for the southern resident killer whales. The designation included approximately 2,500 square miles of Puget Sound, including the entire Strait of Juan de Fuca. Areas with water less than 20 feet deep were not proposed. Also excluded was the Admiralty Inlet naval restricted area. In April 2014, NMFS announced a 90-day finding on a petition to revise SRKW critical habitat to include waters along the U.S. west coast, from Cape Flattery, WA to Point Reyes, CA, that constitute essential foraging and wintering areas (79 FR 22933, April 25, 2014). The petition also requests the adoption of protective in-water sound levels for current and proposed critical habitat. In February 2015, NMFS issued a 12-month finding on this petition, announcing their intent to proceed with the petitioned action to revise SRKW critical habitat. NMFS anticipates publishing a proposed rule in 2017 (80 FR 9682, February 24, 2015).

Resident killer whales of British Columbia and Washington occur as two communities, a northern resident community and a southern resident community. The northern resident community is composed of three clans, A, G, and R with a total of 16 pods. The southern resident community is comprised of a single clan, J-clan made of three pods J1, K1, and L1 (Ford et al. 2000). Population estimates are direct counts of known individuals. The southern resident killer whale population increased to 99 whales in 1995, then declined to 79 whales in 2001 before increasing slightly to 84 whales in 2004 (Ford et al. 2000; Center for Whale Research, unpublished data). About 84 total animals were documented in the J, K, and L pods in 2008; however the minimum population estimate as reported in Carretta et al. (2014) is 85 whales. One birth was recorded in 2008 and seven animals were lost as of October 2008 (Center for Whale Research 2008, NMFS 2008b). Two of these deaths were calves which would not have been counted as part of the population until they were older; females K7 and L21 were 98 and 56 years of age respectively and their deaths were not surprising; the deaths of reproductively active females J11 (35 years old) and L67 (32 years old) were unexpected; and subadult male L101 (5 years old) was attributed to L67 being ill (NMFS 2008b). Two births were reported in February 2009, one in January 2010, and another in February 2010. The most recent stock assessment estimate of 82 whales includes data through 2013 (Carretta et al. 2015). The population fluctuates over time and, as of April 2015, was estimated at 80 individuals, including three new calves (NWFSC 2015). The most recent PBR level for this stock (0.13 whales per year) is based on the minimum population size of 82 multiplied by one-half the default maximum net growth rate for cetaceans (half of 3.2 percent) and a recovery factor of 0.1.

Total annual fishery mortality and serious injury for this stock (0) is not known to exceed 10% of the calculated PBR (0.13) and, therefore, appears to be insignificant and approaching zero mortality and serious injury rate. Although there was one ship strike death in 2006, there were no non-fishery human-caused mortalities or serious injuries reported from 2008 to 2012. The total estimated annual human-caused mortality and serious injury for this stock is, therefore, zero and does not exceed PBR (Carretta et al. 2015). Because the Southern Resident killer whales are formally listed as "endangered" under the ESA, the stock is considered a "strategic" stock under the MMPA. This stock was considered "depleted" prior to its 2005 listing under the ESA.

Distribution and habitat preferences: Killer whales are found in all oceans and are second only to humans as the most widely spread of all mammals (Ford 2009). They are most commonly found in coastal and temperate waters of high productivity. The range of southern resident killer whale DPS extends from Monterey Bay in central California as far north as Southeast Alaska (Carretta et al. 2014). As summarized by Carretta et al. (2014), most sightings of the SRKW stock have occurred in the summer in inland waters of Washington and southern British Columbia. The farthest north SRKW have been documented is off Chatham Strait, Alaska in June 2007. Winter movements and range are poorly known for this stock; however, the J pod is more commonly sighted in inland waters in winter (Ford et al. 2000). The complete winter range of this stock is uncertain although there are indications that animals travel as far south as Monterey, California and as far north as the north coast of British Columbia. Recent satellite tagging studies by NOAA and the Center for Whale Research on an adult male SRKW showed a southward migration to northern California coastal waters during the winter and a northward movement in March to waters off the mouth of the Columbia River (NOAA Fisheries 2013).

Heimlich-Boran (1988) found that resident killer whales in the inland waters of the Pacific Northwest fed more in areas of high substrate topography along salmon migratory routes while transient whales fed in shallow protected areas around concentrations of their prey. The location of food resources and habitats suitable for prey capture appeared to be the prime determining factor in the behavioral ecology of killer whales.

Behavior and life history: Killer whales are very social and the basic social unit is based on matrilineal relationship and linked by maternal decent. A typical matriline is composed of a female, her sons and daughters, and the offspring of her daughters (Ford 2009). Females may live to 80-90 years so a female's line may contain four generations. The pod is the next level of organization that is a group of related matrilines that shared a common maternal ancestor. The next level of social structure is the clan, followed by a resident society.

Births may occur in any month but most are in October-March. Females give birth between 11 and 16 years of age with a 5-year interval between births. Gestation is 15-18 months and weaning is about 1-2 years after birth. Males attain sexual maturity at about 15 years of age. Life expectancy for females is about 50 years with a maximum of 80-90; males typically live to about 29 years of age (Ford 2009; Olesiuk et al. 2000).

The southern residents consume a variety of fish, but salmon, and Chinook salmon in particular, are their primary prey (Ford and Ellis 2006; Hanson et al. 2010). Resident killer whale pods in Puget Sound exhibit cooperative food searching (Hoelzel 1993). Field observations of prey handling and consumption provided strong evidence that resident killer whales are often involved in shared feeding events of all species and sizes of salmonids (Ford and Ellis 2006). Transient killer whales feed on seals, sea lions, and young or smaller cetaceans (Ford 2009) with an optimal group size of at least three whales needed to efficiently chase and capture marine mammal prey. Although killer whales regularly dive to greater than 150 m, there appears to be a trend toward a greater frequency of shallower dives and that males dive deeper than females (Krahn et al. 2004). Seven resident killer whales followed in 2002 were found to have dives that exceeded 228 m with an average maximum depth of 141 m (Baird et al. 2003). Dive rates (number of dives/hour) are similar for males and females and by age and among pods, but dive rates and swim speeds were greater during the day than at night (Baird et al. 2003). Killer whales have no natural predators other than humans but neonatal mortality is high with nearly 46% dying in the first 6 months (Ford 2009).

Acoustics and hearing: Killer whales, like most cetaceans, are highly vocal and use sound for social communication and to find and capture prey. The sounds include a variety of clicks, whistles, and pulsed calls (Ford 2009). As summarized in DON (2008b, and citations therein), the peak to peak source levels of echolocation signals range between 195 and 224 dB re 1 μPa-m. The source level of social vocalizations ranges between 137 to 157 dB re 1 μPa-m. Acoustic studies of resident killer whales in British Columbia have found that there are dialects, in their highly stereotyped, repetitive discrete calls, which are group-specific and shared by all group members (Ford 2009). These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely related whales (Ford 2009). The killer whale has the lowest frequency of maximum sensitivity and one of the lowest high frequency hearing limits known among toothed whales. The upper limit of hearing is 100 kHz for this species.

4.1.11 Killer Whale (*Orcinus orca*) – Transient Ecotype

Please refer to the section above for transient ecotype killer whales regarding description and taxonomy. Transient killer whales, whose range extends over a broader area, primarily hunt marine mammals. Transient pods are usually fewer in number than resident pods, and they typically have different dorsal fin shapes and saddle patch pigmentation than resident pods. As summarized in Allen and Angliss (2014, and references therein) the transient ecotype contains three communities of transient whales within three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients. The West Coast Transient Stock includes animals that occur in California, Oregon, Washington, British Columbia and southeastern Alaska. On many occasions, transient whales from the inland waters of southeastern Alaska have been seen in association with British Columbia/Washington State transients. On other occasions, some of those same British Columbia whales have been sighted with whales more frequently seen off California thus linking these whales by association. Combining the counts of cataloged 'transient' whales gives a minimum number of 243 killer whales belonging to the West Coast Transient stock with a PBR of 2.4 animals per year (Allen and Angliss 2014).

Barlow and Forney (2007) estimated the density of killer whales, regardless of ecotype, at 0.71 killer whales/1000 km^2.

The West Coast transient killer whale stock is not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA. The estimated annual U. S. commercial fishery-related mortality level (0) does not exceed 10% of the PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury (0 animals per year) does not exceed the PBR (2.4). Therefore, the West Coast Transient stock of killer whales is not classified as a "strategic" stock. Population trends and status of this stock relative to its OSP level are currently unknown.

In contrast to resident whales, transient killer whales appear to use passive listening as a primary means of locating prey, call less often, and use high-amplitude vocalizations only when socializing, communicating over long distances, or after a successful attack (Deecke et al. 2002). This probably results from the increased cost to killer whales of warning wary marine mammal prey and reducing the chance of a successful attack (Deecke et al. 2002; DON 2008b).

4.1.12 Killer Whale (*Orcinus orca*) – Offshore Ecotype

Please refer to the descriptions above for offshore ecotype killer whales regarding description and taxonomy.

As summarized in Carretta et al. (2014), the total number of known offshore killer whales occurring from Southeast Alaska through California is 211 animals; this is certainly an underestimate of the total population size because not all animals in this population have been photographed. Based on shipboard line transect surveys in 2005 (Forney 2007) and 2008 (Barlow 2010), the total number of killer whales within 300 nm of the coasts of California, Oregon and Washington is estimated to be 691 animals. Photographs of individual animals can provide a rough estimate of the proportion of whales in each killer whale stock. Using proportions to prorate the line transect abundance estimate yields an estimate of 240 offshore killer whales along California, Oregon and Washington. A minimum abundance estimate for all killer whales along the coasts of California, Oregon and Washington can be estimated from the 2005-2008 line-transect surveys as the 20th percentile of the geometric mean 2005-2008 abundance estimate, or 466 killer whales. Using a prorating of known ecotypes, a minimum of 162 offshore killer whales are estimated to be in U.S. waters off California, Oregon and Washington. No information is available regarding trends in abundance of Eastern North Pacific offshore killer whales. The PBR level is 1.6 offshore killer whales per year.

The status of offshore killer whales in California waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this stock. They are not listed as threatened or endangered under the ESA or as “depleted” under the MMPA. There has been no documented human-caused mortality of this stock, and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and injury for offshore killer whales is zero, therefore, is considered to be insignificant and approaching zero mortality and serious injury rate (Carretta et al. 2013).

4.1.13 Short-Finned Pilot Whale (*Globicephala macrorhynchus*) California, Oregon, Washington Stock

Description: Pilot whales appear black or dark gray; the body is robust with a thick tailstock. The melon is exaggerated and bulbous and there is either no beak or a barely discernible one (Olson 2009). They exhibit striking sexual dimorphism with adult males reaching an average length of 6 m and they are larger than females; the broad-based dorsal fin of a male is larger than that of a female (Olson 2009).

Status and trends: Short-finned pilot whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The abundance of short-finned pilot whales in this region appears to be variable and influenced by prevailing oceanographic conditions. Because animals may spend time outside the U.S. EEZ as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 unweighted average abundance estimate for California, Oregon and Washington waters based on two ship surveys (Barlow 2010; Forney 2007) is 760 (CV=0.64) short-finned pilot whales with a minimum population estimate of 465; the PBR is 4.6 short-finned pilot whales per year. Barlow and Forney (2007) estimated the density of short-finned pilot whales at 0.31 whales/1000 km^2.

The status of short-finned pilot whales off California, Oregon and Washington in relation to OSP is unknown. They have declined in abundance in the Southern California Bight, likely a result of a change in their distribution since the 1982-83 El Niño, but the nature of these changes and potential habitat issues are not adequately understood. Short-finned pilot whales are not listed as threatened or endangered under the ESA or as “depleted” under the MMPA. The average annual human-caused mortality from 2004-2008 is zero animals, less than the PBR of 4.6, and therefore they are not classified as a "strategic" stock under the MMPA. Total annual human-caused mortality and serious injury for this stock is estimated at zero animals, therefore, mortality is considered to be approaching a zero mortality and serious injury rate (Carretta et al. 2014).

Distribution and habitat preferences: The short-finned pilot whale is found in tropical to warm-temperate seas. It usually does not range north of 50° N or south of 40° S. Along the west coast of North America, sightings of short-finned pilot whales north of Point Conception are uncommon but there are infrequent sightings off Oregon and Washington. Worldwide, pilot whales usually are found over the continental shelf break, in slope waters, and in areas of high topographic relief, but movements over the continental shelf and close to shore at oceanic islands can occur.

Behavior and life history: Pilot whales are very social and may travel in groups of several to hundreds of animals, often with other cetaceans. They appear to live in relatively stable, female-based groups (DON 2008b). Sexual maturity occurs at 9 years for females and 17 years for males. The mean calving interval is 4 to 6 years. Pilot whales are deep divers; the maximum dive depth measured is about 971 m (Baird et al. 2002). Short-finned pilot whales feed on squids and fishes. Stomach content analysis of pilot whales in the Southern California Bight consisted entirely of cephalopod remains. The most common prey item identified was *Loligo opalescens*, which has been documented in spawning concentrations at depths of 20-55 m.

Acoustics and hearing: Short-finned pilot whale whistles and clicks have a dominant frequency range of 2 to14 kHz and a source level of 180 dB re 1 µPa-m for whistles (DON 2008b). Globicephala spp. are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007) (Table 4-1).

4.1.14 Baird's Beaked Whale (*Berardius bairdii*) California, Oregon, Washington Stock

Description: Baird's beaked whales are one of the largest members of the family Ziphiidae. The entire body is dark brown with the ventral side paler with irregular white patches; tooth marks of conspecifics are numerous on the back, particularly on adult males (Kasuya 2009). The body is slender with a small head, low falcate dorsal fin and small flippers that fit into depressions on the body. The melon is small and its front surface is almost vertical with a slender projecting rostrum (ibid). Mean body length of whales 15 years or older are 10.5 m in females and 10.1 m in males.

Status and trends: Baird's beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Because the distribution of Baird's beaked whale varies and animals probably spend time outside the U.S. EEZ, a multi-year average abundance estimate is the most appropriate for management within U.S. waters (Carretta et al. 2014). The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the above two ship surveys is 847 (CV=0.49) Baird's beaked whales (Barlow 2010; Barlow and Forney 2007; Forney 2007), with a minimum population estimate of 466 Baird's beaked whales; the PBR is 4.7 Baird's beaked whales per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of Baird's beaked whale at 0.88 whales/1000 km^2.

The status of Baird's beaked whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate trends in abundance (Carretta et al. 2013). No habitat issues are known to be of concern for this species, but in recent years questions have been raised regarding potential effects of human-made sounds on deep-diving cetacean species, such as Baird's beaked whales. In particular, active sonar has been implicated in the mass stranding of beaked whales in the Mediterranean Sea and in the Caribbean. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. Including the one animal that died as the result of a ship strike in 2003, the average annual human-caused mortality in 2004-2008 is zero animals/year. Because recent fishery and human-caused mortality is less than the PBR (6.2), Baird's beaked whales are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is zero and can be considered to be insignificant and approaching zero (Carretta et al. 2014).

Distribution and habitat preferences: Baird's beaked whale is distributed throughout deep waters and along the continental slopes of the North Pacific Ocean (Kasuya 2009). In the eastern North Pacific the northern limits are Cape Navarin (62^{o} N) in the Bering Sea south to just north of northern Baja California. They have been harvested and studied in Japanese waters, but little is known about this species elsewhere. Along the U.S. west coast, Baird's beaked whales have been seen primarily along the continental slope from late spring to early fall. They have been seen less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al. 2014). Baird's beaked whale probably is a slope-associated species. As a result, the area of highest utilization for this whale in the eastern North Pacific is in waters deeper than 500 m. The area of lower utilization is between 200 m to 500 m water depth. There is a rare occurrence in waters shallower than 200 m.

Behavior and life history: Baird's beaked whales occur in relatively large groups of 6 to 30, and groups of 50 or more sometimes are seen (Kasuya 2009). Sexual maturity occurs at about 8 to 10 years, and the calving peak is in March and April (Kasuya 2009). Mating generally occurs in October and November but little else is known of their reproductive behavior (Kasuya 2009). They feed mainly on benthic fishes and cephalopods, but prey also includes pelagic fishes such as mackerel, sardine, and saury (Walker et al. 2002). Baird's beaked whales in Japan prey primarily on deepwater gadiform fishes and cephalopods, indicating that they feed primarily at depths ranging from 800 to 1,200 m (Walker et al. 2002). Baird et al. (2006) reported on the diving behavior of four Blainville's beaked whales (a similar species) off the west coast of Hawaii. The four beaked whales foraged in deep ocean areas with a maximum dive to 1,407 m. Dives ranged from at least 13 min to a maximum of 68 min (Baird et al. 2006).

Acoustics and hearing: DON (2008b) reviewed the literature on beaked whale acoustics and reported that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication. Both whistles and clicks have been recorded from Baird's beaked whales in the eastern North Pacific Ocean. Whistles had fundamental frequencies between 4 and 8 kHz, with 2 to 3 strong harmonics within the recording bandwidth. Pulsed sounds (clicks) had a dominant frequency around 23 kHz, with a second frequency peak around 42 kHz. Baird's beaked whales are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). There is no information on the hearing abilities of Baird's beaked whale.

4.1.15 Mesoplodont Beaked Whales (*Mesoplodon* spp.) California, Oregon, Washington Stocks

Description: At least six species in this genus have been recorded off the U.S. west coast, but due to the rarity of records and the difficulty in identifying these animals in the field, virtually no species-specific information is available (Carretta et al. 2013). The six species known to occur in this region are: Blainville's beaked whale (*M. densirostris*), Perrin's beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubb's beaked whale (*M. carlhubbsi*). Insufficient sighting records exist off the U.S. west coast to determine any possible spatial or seasonal patterns in the distribution of mesoplodont beaked whales. Although they are fairly common in some parts of the ocean, because of their shyness around vessels and unobtrusive behavior, they are rarely observed (Pitman 2009). All have a single tooth in the front to the middle of the jaw. They are relatively small whales ranging in length from about 4 m to 6.2 m, depending on species (Pitman 2009). The body is spindle shaped with a small, usually triangular dorsal fin located approximately two-thirds of the way back on the body. The flippers are small and narrow and fit into pigmented depressions in the body.

Status and trends: Mesoplodont beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Although mesoplodont beaked whales have been sighted along the U.S. west coast on several line transect surveys utilizing both aerial and shipboard platforms, sightings have generally been too rare to produce reliable population estimates, and species identification has been problematic (Barlow 2010; Barlow and Forney 2007; Forney 2007). Previous abundance estimates have been imprecise and biased downward by an unknown amount because of the large proportion of time mesoplodont beaked whales spend submerged, and because the surveys on which they were based covered only California waters, and thus could not include animals off Oregon/Washington. The abundance of Blainville's beaked whales for California, Oregon, and Washington, based on the geometric mean of 2005-2008 surveys is 603 animals. The abundance estimate for mesoplodont beaked whales of unknown species, based on the same 2005-2008 surveys is 421 (CV=0.88). A new trend-based analysis designed to account for the proportion of unidentified beaked whale sightings likely to *Mesoplodon* beaked whales and using a correction factor for missed animals was conducted in 2013 (Moore and Barlow 2013). Based on that analysis and given the strong evidence of a decreasing abundance trend over the 1991-2008 time period, the combined best (50th percentile) estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm in 2008 is 694 (CV=0.65) animals with a minimum population estimate of 389 animals (Carretta et al. 2014). The PBR for this group is 3.9 beaked whales per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of mesoplodont beaked whales at 1.03 whales/1000 km^2.

The status of mesoplodont beaked whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for these species, but in recent years questions have been raised regarding potential effects of human-made sounds on deep-diving cetacean species, such as mesoplodont beaked whales. None of the six species are listed as threatened or endangered under the ESA nor considered "depleted" under the MMPA. Including driftnet mortality only for years after implementation of the Take Reduction Plan (1997-98), the average annual human-caused mortality in 2004-2008 is zero. Because recent mortality is zero, mesoplodont beaked whales are not classified as a "strategic" stock under the MMPA, and the total fishery mortality and serious injury for this stock can be considered to be insignificant and approaching zero. It is likely that the difficulty in identifying these animals in the field will remain a critical obstacle to obtaining species-specific abundance estimates and stock assessments in the future.

Distribution and habitat preferences: Mesoplodont beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean. World-wide, beaked whales normally inhabit continental slope and oceanic waters that are deeper than 200 m (Pitman 2009). Occurrence often has been linked to the continental slope, canyons, escarpments, and oceanic islands (MacLeod and D'Amico 2006). They may associate with strong turbulence caused by rough topography along the slope near Heceta Bank off the Oregon coast but beaked whales are only occasionally reported in waters over the continental shelf (Pitman 2009).

Behavior and life history: They occur alone or in groups of up to 15, and probably calve in the summer. They may be both a mid-water and bottom feeder on squids and fishes (Pitman 2009). Analysis of stomach contents from captured and stranded individuals suggests that beaked whales are deep-diving animals, feeding by suction (Heyning and Mead 1996). Baird et al. (2006) reported on the diving behavior of four Blainville's beaked whales (M. densirostris) off the west coast of Hawaii. The four beaked whales foraged in deep ocean areas (690-3,000 m) with a maximum dive to 1,408 m. Dives ranged from at least 13 min to a maximum of 68 min (Baird et al. 2006).

Acoustics and hearing: Mesoplodon spp. beaked whales are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalization ranges are similar at 300 Hz to 135 kHz (DON 2008a) (Table 4-1).

4.1.16 Cuvier's Beaked Whale (*Ziphius cavirostris*) California, Oregon, Washington Stock

Description: Cuvier's beak whale resembles other beaked whales in that it has a robust, cigar-shaped body with a smallish falcate dorsal fin set about two thirds back; the small flippers fit into a slight depression as with other beaked whales (Heyning and Mead 2009). The head is blunt with a small poorly defined rostrum that grades into a generally sloping melon region (Heyning and Mead 2009). Minimum length at sexual maturity is 5.3 m for females and 5.3 m for males.

Status and trends: Cuvier's beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Previous abundance estimates for this species of beaked whale have been imprecise and biased downward by an unknown amount because of the large proportion of time this species spends submerged, and because the ship surveys on which they were based covered only California waters, and thus could not observe animals off Oregon/Washington. Furthermore, there were a large number of unidentified beaked whale sightings, which were probably either Mesoplodon spp. or Cuvier's beaked whales (Ziphius cavirostris). Updated analyses are based on 1) combining data from two surveys conducted within 300 nm of the coasts of California, Oregon and Washington in 2005 (Forney 2007) and 2008 (Barlow 2010), 2) whenever possible, assigning unidentified beaked whale sightings to *Mesoplodon* spp. or *Ziphius cavirostris* based on written descriptions, size estimates, and 'most probable identifications' made by the observers at the time of the sightings, and 3) estimating a correction factor for animals missed, based on a model of their diving behavior, detection distances, and the searching behavior of observers. A trend-based analysis of line-transect data from surveys conducted between 1991 and 2008 yielded new estimates of Cuvier's beaked whale abundance (Moore and Barlow 2013). The new estimate is substantially higher than previous estimates in part because it accounts for the proportion of unidentified beaked whale sightings likely to be Cuvier's beaked whales and because the correction factor for missed animals was adjusted to account for the fact that the proportion of animals on the trackline missed by observers increases in rough observing conditions. The trend-model analysis incorporates information from the entire 1991-2008 time series for each annual estimate of abundance, and given the strong evidence of a decreasing abundance trend over that time (Moore and Barlow 2013), the best estimate of abundance is represented by the model-averaged estimate for 2008. Based on this analysis, the best (50th percentile) estimate of abundance for Cuvier's beaked whales in 2008 in waters off California, Oregon and Washington was 6,590 (CV=0.55). The minimum population estimate for Cuvier's beaked whale is 4,481 animals with a PBR of 45 whales per year (Carretta et al. 2013). Barlow and Forney (2007) estimated the density of Cuvier's beaked whale at 3.82 whales/1000 km^2.

There is substantial evidence, based on line-transect survey data and the historical stranding record off the U.S. west coast, that the abundance of Cuvier's beaked whales has recently declined in waters off California, Oregon and Washington (Moore and Barlow 2013). Statistical analysis of line-transect survey data from 1991 - 2008 indicates a 0.84 probability of decline during this period, with the mean annual rate of population change estimated to have been −2.9% per year (95% CRI: −8.8% to +3.3%) (Carretta et al. 2014). However, the status of Cuvier's beaked whales in California, Oregon and Washington waters relative to OSP is not known. No habitat issues are known to be of concern for this species, but in recent years questions have been raised regarding potential effects of human-made sounds on deep-diving cetacean species, such as Cuvier's beaked whales. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2004-2008 is zero. Because recent human-caused mortality is less than the PBR, Cuvier's beaked whales are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the PBR and thus can be considered to be insignificant and approaching zero.

Distribution and habitat preferences: Cuvier's beaked whale is distributed in all oceans and seas except the high polar regions. Cuvier's beaked whale generally is sighted in waters >200 m deep, and is frequently recorded at depths >1,000 m. They are commonly sighted around seamounts, escarpments, and canyons (Heyning and Mead 2009). In Hawaii, Cuvier's beaked whales showed a high degree of site fidelity in a study spanning 21 years and showed that there was an offshore population and an island associated population (McSweeney et al. 2007). The site fidelity in the island associated population was hypothesized to take advantage of the influence of islands on oceanographic conditions that may increase productivity (McSweeney et al. 2007). Waters deeper than 1,000 m are the area of highest utilization for the Cuvier's beaked whale in the Northeast Pacific while water depths between 500 m and 1,000 m are less utilized. Occurrence in waters shallower than 500 m is rare (DON 2008b).

Behavior and life history: Little is known of the feeding preferences of Cuvier's beaked whale. They may be mid-water and bottom feeders on cephalopods and, rarely, fish. There is little information on beaked whale reproductive behavior. Recent studies by Baird et al. (2006) show that Cuvier's beaked whales dive deeply (maximum of 1,450 m) and for long periods (maximum dive duration of 68.7 min) but also spent time at shallow depths. Tyack et al. (2006) has also reported deep diving for Cuvier's beaked whales with mean depth of 1,070 m and mean duration of 58 min.

Acoustics and hearing: DON (2008b) reviewed the literature on beaked whale acoustics and reported that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication. Cuvier's beaked whales echolocation clicks were recorded at frequencies from 20 to 70 kHz. There is no information on the hearing abilities of Cuvier's beaked whale. Cuvier's beaked whales are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations ranges are similar at 300 Hz to 135 kHz (DON 2008a) (Table 4-1).

4.1.17 Pygmy Sperm Whale (*Kogia breviceps*) and Dwarf Sperm Whale (*K. sima*) California, Oregon, Washington Stock

Description: Kogia spp. are porpoise-like and robust with a distinctive under-slung lower jaw. Pygmy sperm whales reach a maximum size of about 3.8 m and weight of 450 kg; dwarf sperm whales are smaller at 2.7 m and 272 kg (McAlpine 2009). Adults of both species are bluish-gray to blackish-brown dorsally and light below (ibid). On the side of the head between the eye and the flipper there is a crescent shaped light colored mark referred to as a "false gill." Both species have the shortest rostrum of any cetacean, and the skull is markedly asymmetrical (ibid).

Status and trends: Pygmy and dwarf sperm whales belong to the Order Cetacea, Suborder Odontoceti, and Family Kogiidae. As summarized in Carretta et al. (2014, and citations therein), the most recent abundance estimate for pygmy sperm whales is 579 (CV=1.02) animals and is based on one sighting of an unidentified Kogia during a 2008 ship survey of California, Oregon, and Washington waters (Barlow 2010). Based on previous sighting surveys and historical stranding data, it is likely that these sightings were of pygmy sperm whales. The estimate incorporates a correction factor for animals missed, based on a model of their diving behavior, detection distances, and the searching behavior of observers. Based on this sighting and population estimate of minimum population is 271 pygmy sperm whales with a calculated PBR of 2.7 whales. The lack of recent sightings likely reflects the cryptic nature of this species (they are detected almost exclusively in extremely calm sea conditions), rather than an absence of animals in the region. No human-caused mortality of pygmy sperm whales has been documented during the most recent five-year period (2004-2008) (Carreta et al. 2014).

There is no information on population size for the dwarf sperm whale in the California Current Research Area and thus no minimum population estimate or PBR can be calculated.

Barlow and Forney (2007) estimated the density of Kogia spp. at 1.09 animals/1000 km^2.

The status of pygmy and dwarf sperm whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for these species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. Given the rarity of sightings and fishery interactions in U.S. west coast waters, pygmy and dwarf sperm whales are not classified as a "strategic" stock under the MMPA.

Distribution and habitat preferences: Pygmy and dwarf sperm whales have a worldwide distribution in tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans (McAlpine 2009). Pygmy sperm whales are sighted primarily along the continental shelf edge and over deeper waters off the shelf. However, along the U.S. west coast, sightings of the whales have been rare, although that is likely a reflection of their pelagic distribution and small size rather than their true abundance (Carretta et al. 2014). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge. There are eight confirmed stranding records of Kogia from Oregon and Washington (Carretta et al. 2014).

Behavior and life history: As summarized in DON (2008b, and citations therein) pygmy and dwarf sperm whales probably feed on fishes and invertebrates that feed on the zooplankton in tropical and temperate waters. There is no information on the breeding behavior of either species. Kogia feed on cephalopods and, less often, on deep-sea fishes and shrimps. Kogia make dives of up to 25 min. Median dive times of around 11 minutes have been documented. A satellite-tagged pygmy sperm whale released off Florida was found to make long nighttime dives, presumably indicating foraging on squids in the deep scattering layer (Scott et al. 2001). Most sightings are brief; these whales are often difficult to approach and they actively avoid aircraft and vessels.

Acoustics and hearing: Kogia species are in the high-frequency functional hearing group, with an estimated auditory bandwidth of 200 Hz to 180 kHz (Southall et al. 2007). Vocalizations frequencies range from 13 to 200 kHz (Table 4-1). Recordings of clicks emitted by free-ranging *K. sima* (dwarf sperm whales) in the Lesser Antilles were in the lower end of the range (13-30 kHz). Recordings of stranded pygmy sperm whales were in the 60 to 200 kHz range (DON 2008a).

4.1.18 Sperm Whale (*Physeter macrocephalus*) California, Oregon, Washington Stock

Description: The sperm whale is the largest toothed whale species and the most sexually dimorphic cetacean in body length and weight (Whitehead 2009). Adult females can reach 12 m in length, while adult males measure as much as 18 m in length (Jefferson et al. 1993). The head is large (comprising about one-third of the body length) and squarish. The lower jaw is narrow and under slung. The blowhole is located at the front of the head and is offset to the left. Sperm whales are brownish gray to black in color with white areas around the mouth and often on the belly. The flippers are relatively short, wide, and paddle-shaped. There is a low rounded dorsal hump and a series of bumps on the dorsal ridge of the tailstock and the surface of the body behind the head tends to be wrinkled (Whitehead 2009).

Status and trends: Sperm whales belong to the Order Cetacea, Suborder Odontoceti, and Family Physeteridae. As summarized in Carretta et al. (2014, and citations therein), sperm whales exist in waters of the California Current ecosystem with whales being found year-round in California waters (Dohl et al. 1983; Barlow 1995; Forney et al. 1995), but they reach peak abundance from April through mid-June and from the end of August through mid-November (Rice 1974). Sperm whales are seen off Washington and Oregon in every season except winter (Green et al. 1992). There is limited evidence of sperm whale movement from California to northern areas off British Columbia, but there are no abundance estimates for this area. The most recent abundance estimates for sperm whales off California, Oregon, and Washington, out to 300 nm, derive from trend-model analysis of line-transect data collected during six surveys from 1991 to 2008. Using this method, estimates ranged from 2,000 to 3,000 animals (Moore and Barlow 2014). The best estimate for the California Current (2,106 sperm whales) is the trend-estimate that corresponds with the 2008 survey (Carretta et al. 2015). The minimum population estimate is 1,332 whales and the calculated PBR is 2.7 sperm whales per year (Carretta et al. 2015, Moore and Barlow 2014). Barlow and Forney (2007) estimated the density of sperm whales at 1.70 whales/1000 km^2.

Whaling removed at least 436,000 sperm whales from the North Pacific between 1800 and the end of commercial whaling (summarized in Carretta et al. 2014 and references therein). Of this total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976, and approximately 1,000 were reported taken in land-based U.S. West coast whaling operations. There has been a prohibition on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped earlier, in 1980. As a result of this whaling, sperm whales are formally listed as "endangered" under the ESA, and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The mean annual estimated mortality and serious injury attributable to commercial fisheries interactions was 1.7 sperm whales per year, based on observer and stranding data from 2001 to 2012. There were no documented mortalities or serious injuries of sperm whales due to ship strikes from 2008 to 2012. The annual fishery-related and ship strike mortality and serious-injury is less than PBR, but greater than ten percent of PBR, so cannot be considered insignificant and approaching a zero mortality and serious injury rate (Carretta et al. 2015).

Distribution and habitat preferences: With the exception of humans and killer whales, few animals on earth are as widely distributed as the sperm whale (Whitehead 2009). As summarized in Carretta et al. (2014, and citations therein), sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40^o N in winter. Sperm whales are found year round in California waters, but they reach peak abundance from April through mid-June and from the end of August through mid-November. They were seen in every season except winter (Dec.-Feb.) in Washington and Oregon. Sperm whales were heard in all months of the year from 2004 to 2008 at the offshore acoustic monitoring station off the outer Washington coast (Oleson et al. 2009). Of 176 sperm whales that were marked with Discovery tags off southern California in winter 1962-70, only three were recovered by whalers: one off northern California in June, one off Washington in June, and another far off British Columbia in April. Recent summer/fall surveys in the eastern tropical Pacific show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150o W) and tapers off northward towards the tip of Baja California.

Behavior and life history: Females reach sexual maturity at about age 9 when roughly 9 m long and they give birth about every 5 years; gestation is 14-16 months (Whitehead 2009). Males are larger during the first 10 years and continue to grow well into their 30s, finally reaching physical maturity at about 16 m (ibid). The sperm whale consumes numerous varieties of deep water fish and cephalopods. Sperm whales forage during deep dives that routinely exceed a depth of 400 m and duration of 30 min (Watkins et al. 2002). They are capable of diving to depths of over 2,000 m with durations of over 60 min. Sperm whales spend up to 83 percent of daylight hours underwater. Males do not spend extensive periods of time at the surface. In contrast, females spend prolonged periods of time at the surface (1 to 5 hrs daily) without foraging (Whitehead 2009). An average dive cycle consists of about a 45 min dive with a 9 min surface interval. The average swimming speed is estimated to be 2.5 km/hr.

Acoustics and hearing: As summarized in DON (2008a, and citations therein), sperm whales typically produce short-duration (less than 30 ms), repetitive broadband clicks used for communication and echolocation. These clicks range in frequency from 0.1 to 30 kHz, with dominant frequencies between the 2 to 4 kHz and 10 to 16 kHz ranges. When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Whitehead 2009). Codas are shared between individuals of a social unit and are considered to be primarily for intra-group communication. Neonatal clicks are of low directionality, long duration (2 to 12 ms), low frequency (dominant frequencies around 0.5 kHz) with estimated source levels between 140 and 162 dB re 1 μPa-m rms. Source levels from adult sperm whales' highly directional (possible echolocation), short (100 μs) clicks have been estimated up to 236 dB re 1 μPa-m rms. Creaks (rapid sets of clicks) are heard most frequently when sperm whales are engaged in foraging behavior in the deepest portion of their dives with intervals between clicks and source levels being altered during these behaviors. In summary, sperm whales are in the mid-frequency functional hearing group, with an estimated auditory range of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations, including echolocation clicks, range from 100 Hz to 30 kHz (DON 2008a) (Table 4-1).

4.1.19 Humpback Whale (*Megaptera novaeangliae*) California, Oregon, Washington Stock and the Central North Pacific stock

The humpback whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. No subspecies are recognized. The species is listed as endangered throughout its range. Three relatively distinct stocks migrate between their summer/fall feeding areas and winter/spring calving and mating areas: 1) the California/Oregon/Washington stock (previously known as the Eastern North Pacific stock), which spends the winter/spring in Central America and Mexico and migrates along the west coast from

California to British Columbia during summer and fall; 2) the Central North Pacific stock, which spends winter/spring off the Hawaiian Islands, then migrates to northern British Columbia and Alaska in the summer and fall; and 3) the Western North Pacific stock, which spends winter and spring off of Japan, then probably migrates to waters west of the Kodiak Archipelago in summer and fall. Some individuals from the central North Pacific stock overlap with the summer/fall distribution of the California/Oregon/Washington stock off the coast of Washington and British Columbia (Clapham 2009). Waters off northern Washington may be an area of mixing between the California/Oregon/Washington stock and a southern British Columbia stock (Carretta et al. 2014).

NMFS recently completed a comprehensive status review for humpback whales (80 FR 22304, 21 April, 2015) and proposed to recognize 14 distinct population segments worldwide and remove all but four DPS from the ESA list of species. Under the proposed DPS structure, the California/Oregon/Washington stock would be divided into the Mexico DPS, which would not be listed under the ESA, and the Central America DPS, which would be listed as threatened. The Central North Pacific stock would be the Hawaii DPS and would not be listed under the ESA. The Western North Pacific stock (DPS) would also be listed as threatened.

Description: As summarized by Clapham (2009, and citations therein), humpback whales are large baleen whales with females slightly larger than males. Adult lengths are 16-17 m and calves are about 4 m. Humpback whales are easily recognized at close range by their extremely long flippers, which may be one-third the length of the body. The flippers are white on the bottom and may be white or black on top, depending on the population. The body is black on top with variable coloration ventrally and on the sides. The head and jaws have numerous knobs that are diagnostic for the species. The dorsal fin is small and variable in shape. The underside of the tail exhibits a pattern of white to black that is individually identifiable. The baleen is primarily black and occurs in 270-400 plates on each side of the mouth.

Status and trends: Forney (2007) estimated 1,769 (CV=0.16) humpbacks in the California/Oregon/Washington region based on a 2005 summer/fall ship line-transect survey, which included additional fine-scale coastal strata not included in a 2001 survey. Barlow (2010) estimated 1,090 (CV=0.41) humpback whales from a 2008 summer/fall ship line-transect survey of the same region. The combined 2005 and 2008 line-transect estimate of abundance is the geometric mean of the two annual estimates, or 1,389 (CV=0.21). The current best estimate of 1,918 whales for the California/Oregon/Washington stock is the sum of recent abundance estimates for California/Oregon (1,729) and Washington/southern British Columbia (189) feeding groups (Carretta et al. 2014). The minimum population estimate for humpback whales is based on abundance estimated from line-transect and mark-recapture methods and is approximately 1,876 whales. The population was increasing at a rate of approximately 7.5 percent per year, but recent trends are more variable (Calambokidis and Barlow 2013, Carretta et al. 2014). The PBR level for this stock is calculated as the minimum population size (1,876) times one half the estimated population growth rate for this stock times a recovery factor of 0.1, resulting in a PBR of 22 whales. Because this stock spends approximately half its time outside the U.S. EEZ, the PBR allocation for U.S. waters is 11 whales per year. The species is listed as endangered under the ESA, and consequently the California/Oregon/Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated annual mortality and serious injury due to entanglement (4.4/yr), other anthropogenic sources (zero), plus ship strikes (01.1/yr) in California is less than the PBR allocation of 11 for U.S. waters (Carretta et al 2014). Based on strandings and at sea observations, annual humpback whale mortality and serious injury in commercial fisheries is greater than 10% of the PBR; therefore, total fishery mortality and serious injury is not approaching zero mortality and serious injury rate.

The current best abundance estimate for the Central North Pacific stock of humpback whales is 10,103, based on counts of unique individuals, and the minimum estimate is 7,890 whales. Using a maximum net productivity rate of 0.07 and a recovery factor of 0.3, the calculated PBR for this stock is 82.8 whales (Allen and Angliss 2014b). The minimum population estimate for the Southeast Alaska/northern British

Columbia feeding aggregation component of the Central North Pacific stock is 2,251, with a PBR of 23.6 (Allen and Angliss 2014). The minimum estimated annual mortality and serious injury rate for the entire stock (4.52, with 0.75 commercial fishery-related entanglements in observed fisheries, 7.30 opportunistically-reported entanglements in fishing gear and marine debris in Alaska and Hawaii, and 4.57 opportunistically-reported vessel collisions in Alaska (2.14) and Hawaii (2.43)), does not exceed PBR for this stock. The minimum estimated U.S. commercial fishery-related mortality and serious injury in observed fisheries is less that 10% of PBR and, therefore, considered insignificant and approaching a zero mortality and serious injury rate (Allen and Angliss 20144b).

Distribution and habitat preferences: Surveys conducted by Brueggeman et al. (1992) recorded 36 groups of 68 humpbacks off the Oregon and Washington coasts between May and November. Humpbacks were most abundant between May and September, and no whales were observed during winter. No calves were observed during the surveys. Green et al. (1993) reported 50 groups of 77 humpback whales off the Oregon and Washington coasts between March and April, but did not give their locations relative to the continental shelf. Oleson et al. (2009) reported that winter and spring sightings off the Washington coast were further from shore and in deeper waters than those from summer and fall. Humpback whales are found in all oceans of the world and are highly migratory from high latitude feeding grounds to low latitude calving areas. They are typically found in coastal or shelf waters in summer and close to islands and reef systems in winter (Clapham 2009). Humpbacks primarily occur near the edge of the continental slope and deep submarine canyons, where upwelling concentrates zooplankton near the surface for feeding. However, a single humpback whale was observed in Hood Canal, inside Puget Sound, in January 2012. They often feed in shipping lanes, which makes them susceptible to mortality or injury from large ship strikes (Douglas et al. 2008). About 10% of the whales that were identified off Oregon were also photographed off northern Washington. The results from these surveys showed that humpback whales fed off the Washington coast near the edges of the continental slope or deep canyons from May through September, with the highest numbers in June and July (Calambokidis et al. 2004). However, acoustic detections occurred from late summer through early winter, with detections peaking during October (Oleson et al. 2009).

Barlow and Forney (2007) estimated the density of humpback whales off California, Oregon, and Washington at 0.83 whales/1000 km^2.

Behavior and life history: Humpback whales are known for their spectacular aerial behaviors and complex songs of males. They breed in warm tropical waters after an 11 month gestation period; calves likely feed independently after 6 months. Humpback whales feed on euphausiids and various schooling fishes, including herring, capelin, sand lance, and mackerel (Clapham 2009). As summarized in Clapham (2009, and citations therein) and DON (2008b, and citations therein), humpback whale dives in summer last less than 5 min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min. Although humpback whales have been recorded to dive as deep as about 500 m, on the feeding grounds they spend the majority of their time in the upper 122 m of the water column. On the wintering grounds they dive deeper to 176 m or greater. Like other large mysticetes, they are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with mouths open through the middle.

Acoustics and hearing: Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) sounds made within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Richardson et al. 1995). The main energy of humpback whale songs lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz. Feeding calls, unlike song and social sounds, are highly stereotyped series of narrow-band trumpeting calls. They are 20 Hz to 2 kHz, less than 1 second in duration, and have source levels of 175 to 192 dB re 1 μPa-m. The fundamental frequency of feeding calls is approximately 500 Hz (summarized in DON 2008b, and citations therein). Thus, humpback whales are in the low-frequency functional hearing group, with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). Their vocal repertoire ranges from 20 Hz to greater than 10 kHz (DON 2008a) (Table 4-1).

4.1.20 Blue Whale (*Balaenoptera musculus*) Eastern North Pacific Stock

Description: The blue whale is the largest animal to have ever existed on earth and is found world-wide ranging into all oceans. The largest recorded blue whale from the northern hemisphere was a 28.1 m female; females tend to be larger than males, and southern hemisphere blue whales are larger than those in the north (Sears and Perrin 2009). They have a tapered, elongated shape with a huge broad, relatively flat, U-shaped head. The baleen is black (ibid). The dorsal fin is proportionately smaller than in other baleen whales and varied in shape, ranging from a small nubbin to triangular and falcate positioned far back on the body (Ibid). Underwater they are slate blue; above water they appear mottled light and dark shades of gray.

Status and trends: The blue whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. The size of the feeding stock of blue whales off the U.S. west coast was estimated recently by both line transect and mark-recapture methods (Carretta et al. 2014). Because some fraction of the population is always outside the survey area, the line-transect and mark recapture estimation methods provide different measures of abundance for this stock. Line transect estimates reflect the average density and abundance of blue whales in the study area during summer and autumn surveys, while mark recapture estimates provide an estimate of total population size. The best estimate of blue whale abundance in the U.S. West Coast feeding stock component of the Eastern North Pacific stock is 1,647 for 2008 to 2011 (Calambokidis and Barlow 2013, Carretta et al. 2014). The minimum population is approximately 1,551 blue whales with a calculated PBR of 9.3 (Carretta et al. 2014). Because whales in this stock spend approximately three quarters of their time outside the U.S. EEZ, the PBR allocation for U.S. waters is one-quarter of this total, or 2.3 whales per year. Barlow and Forney (2007) estimated the density of blue whales at 1.36 whales/1000 km^2.

As summarized in Carretta et al. (2014, and references therein), the reported take of North Pacific blue whales by commercial whalers totaled 9,500 between 1910 and 1965. Approximately 3,000 of these were taken from the west coast of North America from Baja California, Mexico to British Columbia, Canada. Blue whales in the North Pacific were given protected status by the IWC in 1966. As a result of commercial whaling, blue whales were listed as "endangered" under the Endangered Species Conservation Act of 1969. This protection was transferred to the ESA in 1973. They are still listed as endangered, and consequently the Eastern North Pacific stock is automatically considered as a depleted and strategic stock under the MMPA. The average annual incidental mortality and serious injury rate from ship strikes (1.9/year for 2007-2011) is less than the calculated PBR for this stock. This rate, however, does not include unidentified large whales struck by ships, so the actual number may exceed PBR. There have been no reported blue whale mortalities associated with commercial fisheries and the total fishery mortality and serious injury rate is approaching zero (Carretta et al. 2014).

Distribution and habitat preferences: The blue whale has a worldwide distribution in circumpolar and temperate waters. They undertake seasonal migrations and were historically hunted on their summer, feeding areas. It is assumed that blue whale distribution is governed largely by food requirements and that populations are seasonally migratory. Pole-ward movements in spring allow the whales to take advantage of high zooplankton production in summer. Movement toward the subtropics in the fall allows blue whales to reduce their energy expenditure while fasting and to avoid ice entrapment. For the California Current ecosystem as defined in Carretta et al. (2013), the Eastern North Pacific Stock of blue whales includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific. This definition is consistent with both the distribution of the northeastern call type and with the known range of photographically identified individuals. Based on locations where the northeastern call type has been recorded, some individuals in this stock may range as far west as Wake

Island and as far south as the Equator. The U.S. west coast is certainly one of the most important feeding areas in summer and fall, but, increasingly, blue whales from this stock have been found feeding to the north and south of this area during summer and fall. Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome (a large, 300-500 km^2, relatively stationary eddy centered near 9° N and 89° W).

Behavior and life history: Blue whales reach sexual maturity at 5-15 years of age; length at sexual maturity in the Northern Hemisphere for females is 21-23 m and for males it is 20-21 m (Sears and Perrin 2009). Females give birth about every 2-3 years in winter after a 10-12 month gestation; longevity is thought to be at least 80-90 years (ibid). Blue whales occur primarily in offshore deep waters (but sometimes near shore, e.g., the deep waters in Monterey Canyon, CA) and feed almost exclusively on euphausiids. Croll et al. (2001) determined that blue whales dived to an average of 141 m and for 7.8 min when foraging and to 68 m and for 4.9 min when not foraging. Data from southern California and Mexico showed that whales dove to > 100 m for foraging. Calambokidis et al. (2003) deployed tags on blue whales and collected data on dives as deep as about 300 m.

Acoustics and hearing: Blue whales, along with other mysticetes, are in the low-frequency functional hearing group, with an estimated auditory range of 7 Hz to 22 kHz (Southall et al. 2007). Their vocalizations range from 12 Hz to 400 Hz, with a dominant range of 12-25 Hz (DON 2008a) (Table 4-1).

4.1.21 Fin Whale (*Balaenoptera physalus*) California, Oregon, Washington Stock

Description: Fin whales are sexually dimorphic with females about 10-15% longer than males; in the Northern Hemisphere female length is about 22.5 m and for males 21 m (Aguillar 2009). Fin whales are slender with a narrow rostrum, a falcate fin located at 75% of total length; it is higher than the blue whale but lower than the sei whale (ibid). The ventral grooves are numerous and extend from the chin to the umbilicus. The pigmentation of the head region is strikingly asymmetrical whereas the left side, dorsal and ventral, is dark slate and the right side dorsal is light gray and the right ventral is white (ibid). The pigmentation also is shown in the baleen plates, which are gray and yellowish.

Status and trends: The fin whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. As summarized in Carretta et al. (2014, and references therein), the best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nm is 3,051 whales for 2008, based on trend-model analysis of line-transect data from 1991-2008. The minimum population estimate is 2,598 fin whales with a calculated PBR of 16 whales per year (Carretta et al. 2014). Barlow and Forney (2007) estimated the density of fin whales off California, Oregon, and Washington at 1.84 whales/1000 km^2.

Fin whales in the entire North Pacific were estimated to be at less than 38% (16,625 out of 43,500) of historic carrying capacity (Mizroch et al. 1984). The initial abundance has never been estimated separately for the "west coast" stock, but this stock was also probably depleted by whaling. Approximately 46,000 fin whales were taken from the North Pacific by commercial whalers between 1947 and 1987. Approximately 5,000 fin whales were taken from the west coast of North America from 1919 to 1965. Fin whales in the North Pacific were given protected status by the IWC in 1976. Fin whales are formally listed as "endangered" under the ESA, and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The total incidental mortality due to fisheries (0.6/yr) and ship strikes (1.6/yr) from 2007 to 2011 is less than the PBR. Total fishery mortality is less than 10% of PBR and the mortality and serious injury rate may be approaching zero (Carretta et al. 2014). There is some indication that the population may be growing.

Distribution and habitat preferences: As summarized in DON (2008b, and references therein), fin whales occur in oceans of both Northern and Southern Hemispheres between 20–75° N and S latitudes. Fin whales are distributed widely in the world's oceans. In the northern hemisphere, most migrate seasonally from high Arctic feeding areas in summer to low latitude breeding and calving areas in winter. During the summer in the North Pacific Ocean, fin whales are distributed in the Chukchi Sea, around the Aleutian Islands, the Gulf of Alaska, and along the coast of North America to California. The fin whale is found in continental shelf and oceanic waters. Globally, it tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually. Fin whales in the North Pacific spend the summer feeding along the cold eastern boundary currents. The North Pacific population summers from the Chukchi Sea to California, and winters from California southward.

Behavior and life history: Fin whales become sexually mature between six to ten years of age, depending on density-dependent factors. Reproduction occurs primarily in the winter. Gestation lasts about 11 months and nursing occurs for 6 to 11 months (Aguillar 2009). Fin whales typically dive for 5 to 15 min, separated by sequences of 4 to 5 blows at 10 to 20 second intervals. Goldbogen et al. (2006) reported that fin whales in California made foraging dives to a maximum of 228-271 m and dive durations of 6.2-7.0 min. Fin whale dives likely coincide with the diel migration of krill. Fin whales feed on planktonic crustaceans, including *Thysanoessa* sp. and *Calanus* sp., as well as schooling fish including herring, capelin and mackerel (Aguilar 2009).

Acoustics and hearing: Fin whales are in the low-frequency functional hearing group, with an estimated auditory range of 7 Hz to 22 kHz (Southall et al. 2007). They also vocalize at low frequencies of 15-30 Hz (DON 2008a) (Table 4-1).

4.1.22 Sei Whale (*Balaenoptera borealis*) Eastern North Pacific Stock

Description: The sei whale is a typical sleek rorqual and is the third largest whale (behind blue and fin) reaching a maximum length of about 20 m and weighing 20 tons; the dorsal fin is larger than that of the blue and fin but all three species may be confused at sea (Horwood 2009). There is a single prominent ridge on the rostrum and a slightly arched rostrum with a downturned tip. They are dark gray dorsally and on the ventral surfaces of the flukes and flippers (ibid). There is no whitening of the lower lip as in fin whales and the baleen is dark gray, often with a yellowish-blue hue; but some white baleen may occur in some individuals (ibid).

Status and trends: The sei whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. As summarized in Carretta et al. (2014, and references therein) only nine confirmed sightings of sei whales were made in California, Oregon, and Washington waters during extensive ship and aerial surveys between 1991-2008. Green et al. (1992) did not report any sightings of sei whales in aerial surveys of Oregon and Washington. Abundance estimates for the two most recent line transect surveys of California, Oregon, and Washington waters out to 300 nm are 74 (CV=0.88) and 215 (CV=0.71) sei whales, respectively (Forney 2007, Barlow 2010). The best estimate of abundance for California, Oregon, and Washington waters out to 300 nm is the unweighted geometric mean of the 2005 and 2008 estimates, or 126 (CV=0.53) sei whales (Barlow and Forney 2007 ; Forney 2007; Barlow 2010).with a minimum population estimate of 83; the calculated PBR is 0.17 sei whales per year. Barlow and Forney (2007) estimated the density of sei whales at 0.09 whales/1000 km^2.

Previously, sei whales were estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific. The initial abundance has never been reported separately for the Eastern North Pacific stock, but this stock was also probably depleted by whaling. The reported take of North Pacific sei whales by commercial whalers totaled 61,500 between 1947 and 1987. Of these, at least 410 were taken by-shore-based whaling stations in central California between 1919 and 1965. There has been an IWC prohibition on taking sei whales since 1976, and commercial whaling in the U.S. has been prohibited since 1972. Sei whales are formally listed as "endangered" under the ESA, and consequently the Eastern North Pacific stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. Total estimated fishery mortality is zero and therefore is approaching zero mortality and serious injury rate (Carretta et al 2014). Although the current rate of ship strike deaths and serious injuries is zero, it is likely that some sei whale ship strikes are unreported.

Distribution and habitat preferences: As summarized in Horwood (2009) and DON (2008a,b), sei whales have a worldwide distribution but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 2009). Sei whales spend the summer months feeding in subpolar higher latitudes and return to lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males. For the most part, the location of winter breeding areas is unknown.

Behavior and life history: Sei whales mature at about 10 years for both sexes. They are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges. On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 2009). In the North Pacific, sei whales feed along the cold eastern currents (Perry et al. 1999). Prey includes calanoid copepods, krill, fishes, and squids. The dominant food for sei whales off California during June through August is the northern anchovy, while in September and October they eat mainly krill. There are no reported diving depths or durations for Sei whales.

Acoustics and hearing: Sei whales are in the low-frequency hearing group, along with other baleen whales, with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). There are few recordings of sei whale vocalizations in the North Pacific, where the sweep frequency ranged from 1.5 to 3.5 kHz (DON 2008a) (Table 4-1).

4.1.23 Common Minke Whale (*Balaenoptera acutorostrata scammoni*) California, Oregon, Washington Stock

Description: As summarized by Perrin and Brownell (2009, and citations therein), the North Pacific minke whale is the second smallest baleen whale with females somewhat larger than males. Females have been measured at 8.5 m and males at 7.9 m and weigh about 10 tons. The body is dark gray to brownish dorsally and white to cream ventrally; the flipper has a white chevron that is diagnostic. The baleen is white and short and numbers between 230-360 plates; the dorsal fin is relatively tall and falcate and located forward on the posterior one-third of the body. The rostrum is very narrow and pointed (thus the species name acutorostrata).

Status and trends: The common minke whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. They are widely distributed in all oceans with three recognized subspecies, one in the North Atlantic (B. a. acutorostrata), one in the North Pacific (B. a. scammoni), and one around the Antarctic Peninsula (B. acutorostrata) where it is known as the dwarf minke whale (Acevedo et al. 2011). A second minke whale species is recognized in the southern hemisphere as the Antarctic minke whale (B. bonaerensis). Because ‘resident’ minke whales from California to Washington appear behaviorally distinct from migratory whales further north, minke whales in coastal waters of California, Oregon, and Washington are considered a separate stock (Carretta et al. 2013).

The number of minke whales in this stock has been estimated to be 478 whales with a minimum population estimate of 202 whales; the calculated PBR for this stock is 2 whales (Carretta et al. 2014). They typically occur as single animals, rather than in groups. Barlow and Forney (2007) estimated the density of minke whales at 0.72 whales/1000 km^2.

The annual mortality due to fisheries (0.0/yr) and ship strikes (0.0/yr) is less than the calculated PBR for this stock (2.0), so they are not considered a "strategic" stock under the MMPA. Fishery mortality is less than 10% of the PBR; therefore, total fishery mortality is approaching zero mortality and serious injury rate (Carretta et al. 2014).

Distribution and habitat preferences: Minke whales are common and the most numerous baleen whales found throughout the world. In the Northeast Pacific Ocean, minke whales range from the Chukchi Sea south to Baja California (Perrin and Brownell 2009). They occur year-round off California. The minke whales found in waters off California, Oregon, and Washington appear to be resident in that area, and to have home ranges, whereas those farther north are migratory. The minke whale generally occupies waters over the continental shelf, including inshore bays and estuaries (ibid). However, based on whaling catches and surveys worldwide, there is also a deep-ocean component to the minke whale's distribution. Minke whales appear to establish home ranges in the inland waters of Washington and along central California, and exhibit site fidelity to these areas. In Puget Sound they may be seen during all months but are most often seen during March through November (Calambokidis and Baird 1994). Little is known of specific habitat preferences for minke whales but they are seen in coastal, continental shelf, and deep pelagic waters. They are common but not numerous visitors to Puget Sound with 'resident' identifiable minke whales commonly observed in the San Juan Islands.

Behavior and life history: Little is known of the natural history of minke whales. They are assumed to breed in winter in warm waters of low latitudes, give birth to a single calf every other year, and reach sexual maturity when 7-9 m long (Osborne et al. 1988, Perrin and Brownell 2009). Minke whales in the North Pacific typically prey on euphausiids, Japanese anchovy, Pacific saury, walleye pollock, small fishes, and squids (Perrin and Brownell 2009). There are no data on dive depth for minke whales. Minke whales are predated upon by killer whales.

Acoustics and hearing: Minke whales are in the low-frequency functional hearing group with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). Vocalizations range from 60 Hz to 20 kHz (DON 2008a) (Table 4-1).

4.1.24 Gray Whale (*Eschrichtius robustus*) Eastern North Pacific Stock

Description: The gray whale is a robust, slow-moving whale recognized by a mottled gray color with numerous light patches scattered along the body and lack of a dorsal fin (Jones and Swartz 2009). They have more external parasites and epizoites than any other cetacean (Jones and Swartz 2009). Instead of a dorsal fin, they have a low hump, followed by a series of 10 or 12 knobs along the dorsal ridge of the tail, which are easily seen when the animal arches to dive. The baleen is short (5-40 cm), thick, and coarse and is cream-white to yellow. The upper jaw has 130-180 baleen plates (Jones and Swartz 2009). Adults are 10-15 m long and weigh between 16 and 45 tons. At birth, the calves are 5 m long and weigh close to 450 kg. Both male and female gray whales reach sexual maturity when they are between five and 11 years old, with the average being eight years (Rice 1986).

Status and trends: Gray whales belong to the Order Cetacea, Suborder Mysticeti, and Family Eschrichtiidae. There are two populations, the western North Pacific (WNP) population that migrates along Asia and into the Okhotsk Sea, and the Eastern North Pacific (ENP) population that migrates along the coasts of eastern Siberia, North America, and Mexico. Over 20,000 gray whales swim through the California Current ecosystem each year during their annual migration from feeding grounds in the Bering Sea to calving bays in Baja California. Of these a small number remain along the Canadian/Washington/Oregon coast to feed and explore, of which an even smaller number swim into Puget Sound and into and through Admiralty Inlet. On June 16, 1994, the Eastern North Pacific gray whale population was formally removed from the List of Endangered and Threatened Wildlife, as it was no longer considered "endangered" or "threatened" under the ESA. The stock is stable or increasing. The most recent abundance estimates are based on counts made during the 2007/2008, 2009/2010, and 2010/2011 southbound migrations. The most recent estimate of abundance, from the 2010/2011 southbound survey is 20,990 whales, with a minimum population estimate of 20,125; the calculated PBR for this stock is 624 gray whales (Carretta et al. 2015).

The total estimated annual level of human-caused mortality and serious injury for ENP gray whales, 2008-2012, was 133 and includes Russian harvest (127), mortality from commercial fisheries (4.45), and ship strikes (2.0) Since this level does not exceed the PBR (624), the ENP stock of gray whales is not classified as a "strategic" stock. Levels of human-caused mortality and serious injury resulting from commercial fisheries and ship strikes for ENP whales represent minimum estimates as recorded by stranding networks or at-sea sightings (Carretta et al. 2015).

The presence of individuals from the western North Pacific (WNP) stock of gray whales in the NWFSC research areas is considered extralimital. During summer and fall, the WNP stock feeds in the Okhotsk Sea, Russia. Historically, wintering areas included waters off Korea, Japan, and China. Recent tagging, photo-identification, and genetics studies revealed that some WNP gray whales migrate to the eastern North Pacific (ENP) in winter, including waters off Canada, the U.S., and Mexico (Lang et al. 2011, Mate et al. 2011, Weller et al. 2012, Urbán et al. 2013). Combined, these studies include 27 individual WNP gray whales in the ENP (Carretta et al. 2015).

The WNP stock is listed as endangered. Based on photo-identification studies off Sakhalin Island, Russia, estimated abundance is 140, with a minimum estimate of 135 WNP gray whales off Sakhalin (Carretta et al. 2015 and citations therein). The calculated PBR of 0.06 WNP gray whales per year includes multipliers that account for an estimated proportion of the population that uses the U.S. EEZ (0.575) and the proportion of the year those whales are in the U.S. EEZ (3 months, or 0.25 years) (Carretta et al. 2015).

Distribution and habitat preferences: The gray whale migration covers 8,000-10,000 km each way (Rugh et al. 1999), perhaps the longest migration of any mammalian species. Most eastern North Pacific gray whales spend the summer in the shallow waters of the northern and western Bering Sea and in the adjacent waters of the Arctic Ocean; however, as mentioned above, some remain throughout the summer and fall along the Pacific coast as far south as southern California. These whales are designated as the Pacific Coast Feeding Aggregation and have been shown by photo-identification studies to 1) move widely within and between areas on the Pacific coast to feed in the summer and fall, 2) are not always observed in the same area each year, and 3) may have several year gaps between resightings in studied areas (Quan 2000). Gray whales are by far the most coastal of all the great whales, and inhabit primarily inshore or shallow, offshore continental shelf waters of the North Pacific. They tend to be nomadic, highly migratory, and tolerant of climate extremes (Jones and Swartz 2009

Behavior and life history: Female gray whales usually breed once every two years. The breeding season is limited primarily to a three-week period in late November and early December near the start of the southward migrations. However, if no conception occurs at that time, a second estrus cycle can occur within 40 days (Rice and Wolman 1971), such that a few females may breed as late as the end of January on the winter grounds (Jones and Swartz 2009). Gray whale calves are born in the winter after a gestation period of about 13.5 months. Killer whale predation may be the most significant cause of mortality (ibid). The gray whales that feed within Puget Sound typically use shallow areas close to shore for feeding on herring eggs and larvae, crab larvae, ghost shrimp, amphipods and crustaceans.

Acoustics and hearing: As summarized in Jones and Swartz (2009) and DON (2008b, and references therein), gray whales produce broadband signals ranging from 100 Hz to 4 kHz (and up to 12 kHz). The most common sounds on the breeding and feeding grounds are knocks which are broadband pulses from about 100 Hz to 2 kHz and most energy at 327 to 825 Hz (Richardson et al. 1995). The source level for knocks is approximately 142 dB re 1 μPa-m. During migration, individuals most often produce low-frequency moans. The structure of the gray whale ear is evolved for low-frequency hearing. Gray whale responses to noise include changes in swimming speed and direction to move away from the sound source; abrupt behavioral changes from feeding to avoidance, with a resumption of feeding after exposure; changes in calling rates and call structure; and changes in surface behavior, usually from traveling to milling.

4.2 Pinnipeds

4.2.1 California Sea Lion (*Zalophus californianus*) U.S. Stock

Description: California sea lions are highly sexually dimorphic; the weight and length of males is about 350 kg and 2.4 m compared to females at 100 kg and 1.8 m, respectively (Heath and Perrin 2009). Male and female pups weigh 6-9 kg. Adult males usually are a dark brown, but can range from light brown to black; females are dark brown to black (Heath and Perrin 2009). Males typically have a distinguishing sagittal crest on top of the head often topped with white fur.

Status and trends: The California sea lion belongs to the Order Carnivora, Suborder Pinnipedia, Family Otariidae and includes three subspecies of which Z. c. californianus (found from southern Mexico to southwestern Canada) occurs in the California Current ecosystem. California sea lions breed on islands in three geographic regions which are used to separate this subspecies into five stocks: (1) the United States (Pacific Temperate) stock begins at the United States/Mexico border and extends northward into Canada; (2) the Western Baja California (Pacific Subtropical) stock which extends from the United States/Mexico border to the southern tip of the Baja California Peninsula; and (3) three Gulf of California stocks which includes the Southern Gulf of California, Central Gulf of California, and the Northern Gulf of California (Carretta et al. 2013). Based on extrapolations from pup counts, the population is estimated at 296,750 sea lions, and it is increasing at 5.4 percent per year (Carretta et al. 2014). The minimum population estimate for the U.S. stock is 153,337 sea lions. The calculated PBR for this stock is 9,200 animals (Carretta et al. 2014). Revised estimates of total population size are currently being developed based on 2011 pup counts of 61,943 animals (Carretta et al. 2015).

California sea lions in the U.S. are not listed as "endangered" or "threatened" under the ESA or as "depleted" under the MMPA. The total fishery mortality (331) is less than 10% of the PBR and so is considered to be insignificant and approaching a zero mortality and serious injury rate (Carretta et al. 2015). Other sources of human-caused mortality (e.g., shootings, direct removals, recreational hook-and-line fisheries, tribal takes, entrainment in power plant intakes, incidental research takes) account for an average of 58 sea lions per year, 2008-2012. California sea lions are not considered a "strategic" stock under the MMPA because total human-caused mortality is likely to be less than the PBR (9,200).

Distribution and habitat preferences: The primary rookeries are located on the California Channel Islands of San Miguel, San Nicolas, Santa Barbara, and San Clemente. As summarized in Carretta et al. (2011) and DON (2008b, and references therein), their distribution shifts to the northwest in fall and to the southeast during winter and spring, probably in response to changes in prey availability. In the non-breeding season, adult and subadult males migrate northward along the coast to central and northern California, Oregon, Washington, and Vancouver Island and return south the following spring; they are occasionally sighted hundreds of kilometers offshore. Females and juveniles tend to stay closer to the rookeries. They also enter bays, harbors, and river mouths and often haul out on man-made structures such as piers, jetties, offshore buoys, and oil platforms (Riedman 1990). California sea lions in the Puget Sound haul out on log booms and U.S. Navy submarines, and are often seen rafted off river mouths (Jeffries et al. 2000). They are occasionally sighted up to several hundred kilometers offshore. California sea lions frequently travel up river systems in search of prey and are common at Bonneville Dam, 230 miles upriver from the mouth of the Columbia River, consuming migrating salmonids during winter and spring (NMFS 2008b). Thirty nine adult males were seen there in 2012 (Stansell et al. 2012).

Behavior and life history: California sea lion numbers ashore increase rapidly in May when males establish breeding territories. Birth to a single pup occurs from May through June and pups are weaned in about 10-12 months (Heath and Perrin 2009). While near rookeries in California, females typically feed over the continental shelf and travel within 54 km from the islands but are known to travel as far north as Monterey Bay to feed during the breeding season (Antonelis et al. 1990; Melin and DeLong 2000). California sea lions feed primarily on Pacific whiting, Pacific herring, salmonids, spiny dogfish, and squids. Dives off rookeries in California typically last about 2 minutes but can be as long as 10 minutes; dive depths average about 26-98 m, but can be well over 200 m (Heath and Perrin 2009). Females are known to dive to a maximum depth of 482 m for up to 16 minutes while foraging during the non-breeding period (Melin et al. 2008).

Acoustics and hearing: California sea lions are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4-1).

4.2.2 Steller Sea Lion (*Eumetopias jubatus*) Eastern Distinct Population Segment (DPS)

Description: Steller sea lions exhibit significant sexual dimorphism with males larger. Average length of males is 2.8 m and females 2.4 m (maximum of about 3.3 m and 2.9 m, respectively). Estimated average weight of males is 566 kg and of females 263 kg (maximum of about 1,120 kg and 350 kg, respectively). Pup weight at birth is 16-23 kg and may be slightly larger in the western part of their range. Pups are born with a wavy, chocolate brown fur that molts after 3-6 months of age. Adult fur color varies between a light buff to reddish brown with most of the under parts and flippers a dark brown to black; naked parts of the skin are black. Both sexes become blonder with age. Adult males have long, coarse hair on the chest, neck, and shoulders that are massive and muscular (Loughlin 2009).

Steller sea lions belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae. As the result of an analysis by Loughlin (1997) two separate stocks of Steller sea lions were recognized within U. S. waters: an eastern U. S. stock, which includes animals east of Cape Suckling, Alaska (144°W), and a western U. S. stock, which includes animals at and west of Cape Suckling. All genetic analyses and other data confirm a strong separation between western and eastern stocks such that the IUCN and the Society for Marine Mammalogy support elevating the two recognized stocks to the subspecies level in which case the vernacular name for the eastern DPS/subspecies may become Loughlin's northern sea lion (*Eumetopias jubatus monteriensis*, Phillips et al. 2009); the western DPS/subspecies is to remain as Steller sea lion. However, as the vernacular designation of the eastern DPS/subspecies as Loughlin's northern sea lion is new, the vernacular "eastern stock of Steller sea lion" will be used in this document.

Status and trends: The eastern stock of Steller sea lion was listed as threatened under the ESA but was removed from the list of endangered and threatened species in December 2013; the western subspecies (E. j. jubatus) remains listed as endangered (78 FR 66140, November 4, 2013). Delisting the eastern stock of Steller sea lions did not remove or modify Steller sea lion critical habitat, designated in 1993 (58 FR 45269, August 27, 1993). Existing critical habitat designation will remain in place until NMFS undertakes a separate rulemaking to consider amending designation (78 FR 66140, November 4, 2013). Based on extrapolations from non-pup and pup surveys, the total population of the eastern stock of Steller sea lions is estimated to be within the range of 63,160-78,198 with a minimum population estimate of 57,966 and a PBR of 1,552 animals (Allen and Angliss 2014). Overall the stock has increased at about 4.18 percent per year between 1979 and 2010 based on an analysis of pup counts in California, Oregon, British Columbia and Southeast Alaska (NMFS Eastern DPS Status review 2012). The eastern U.S. stock increase has been driven by growth in pup counts in all regions (NMFS 2012).

Steller sea lions from the EDPS have been taken historically in the California (CA)/Oregon (OR) thresher shark and swordfish drift gillnet, WA/OR/CA groundfish trawl, northern Washington (WA) marine set gillnet, and Gulf of Alaska sablefish longline fisheries, although no mortalities were reported by fishery observers monitoring drift gillnet and set gillnet fisheries in Washington and Oregon this decade. The total mean annual mortality rate from all U.S commercial fisheries is 17.0 Steller sea lions. Based on currently available data, the minimum estimated U. S. commercial fishery-related mortality and serious injury for this stock of 17.0 animals is less than 10% of the calculated PBR (10% of PBR = 155 or 207) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate.

Steller sea lions have been observed preying on salmonids and white sturgeon at the Bonneville Dam, over 200 kilometers up the Columbia River (Stansell et al. 2010). In 2008, two Steller sea lions died in traps at Bonneville Dam as part of the lethal take program targeting California sea lions (Allen and Angliss 2014). These mortalities occurred in the course of permitted “nuisance animal” removal projects and were not the result of NWFSC fisheries research activities that are addressed by this application.

The estimated annual level of total human-caused mortality and serious injury (49 (commercial and recreational fisheries) + 11.9 (subsistence) + 4.2 (other human-caused mortality) = 65.1) does not exceed the PBR (1,552 or 2,069) for this stock (Allen and Angliss 2014).

Distribution and habitat preferences: Steller sea lions occur throughout the North Pacific Ocean rim from Japan to southern California. They abound on numerous breeding sites (rookeries) in the Russian Far East, Alaska, and British Columbia with fewer numbers in Oregon and California. Seal Rocks in Prince William Sound, Alaska is the northernmost (60° 09' N) rookery and Año Nuevo Island, California, the southernmost (37° 06' N) (Loughlin et al. 1987, Loughlin 2009). The eastern subspecies occurs year round in the CCRA, with peak numbers in late summer, fall, and winter (Carretta et al. 2014). The species does not breed in Washington although pups have been observed at one haulout site in 1997 and 1998; rookeries are in northern British Columbia, central Oregon, and central and northern California where pupping occurs from late May through early July. Steller sea lions frequently travel up river systems in search of prey and are common and increasing in number at Bonneville Dam, 230 miles upriver from the mouth of the Columbia River, consuming migrating salmonids during winter and spring (NMFS 2008b). Seventy three adult males were seen there in 2012 (Stansell et al. 2012).

Unlike their more gregarious cousin the California sea lion, Steller sea lions tend to avoid people and prefer isolated offshore rocks and islands to breed and rest. Although rookeries and rest sites occur in many areas, principally on exposed rocky shorelines and wave-cut platforms, the locations used are specific and change little from year to year. Steller sea lions tend to return to their birth island as adults to breed, but they range widely (some yearlings have been seen > 1,000 km from their birth rookery) during their first few years and during the non-breeding season (Loughlin 2009).

Steller sea lions exhibit two general types of distribution at sea: 1) less than 20 km from rookeries and haulout sites for adult females with pups, pups, and juveniles, and 2) larger areas (greater than 20 km) where these and other animals may range to find optimal foraging conditions once they are no longer tied to rookeries and haulout sites for nursing and reproduction (Call and Loughlin 2004). Telemetry studies show that in winter, adult females may travel far out to sea into water greater than 1,000 m deep (Merrick and Loughlin 1997), and juveniles less than 3 years of age travel nearly as far (Loughlin et al. 2003). Sea lions commonly occur near and beyond the 200 m depth contour. Some individuals may enter rivers in pursuit of prey.

Behavior and life history: Steller sea lions breed from late May to early July throughout the range at rookeries located on remote islands and rocks. One pup is born annually after a 9 month gestation period. As with most pinnipeds, embryo implantation typically is delayed 3 months. Pups are weaned prior to the breeding season but some may remain with their mothers for 2-3 years (Loughlin 2009). They are opportunistic predators, feeding primarily on a wide variety of fishes and cephalopods. Some of the more important prey species include Pacific whiting, walleye pollock, Atka mackerel, Pacific herring, capelin, Pacific sand lance, Pacific cod, and salmon (ibid). Steller sea lions have been known to prey infrequently on harbor seal, fur seal, ringed seal, and possibly sea otter pups.

Compared to other pinnipeds, Steller sea lions tend to make relatively shallow dives, with few dives recorded to depths greater than 250 m. Maximum depths recorded for individual adult females in summer are in the range from 100 to 250 m; maximum depth in winter is greater than 250 m. The maximum depth measured for yearlings in winter was 72 m and average depths are near 18 m and in shallow near-shore waters (Loughlin et al. 2003).

Acoustics and hearing: Steller sea lions have similar hearing thresholds in-air and underwater to other otariids. Hearing in air ranges from 0.250–30 kHz, with a region of best hearing sensitivity from 5–14.1 kHz (Muslow and Reichmuth 2010). The underwater audiogram shows the typical mammalian U-shape. The range of best hearing was from 1 to 16 kHz. Higher hearing thresholds, indicating poorer sensitivity, were observed for signals below 16 kHz and above 25 kHz (Kastelein et al. 2005). Like other pinnipeds, sea lions are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4-1).

4.2.3 Guadalupe Fur Seal (*Arctocephalus townsendi*)

Description: Adult female Guadalupe fur seals weigh about 49 kg and males 124 kg (Arnould 2009). Fur seals in general can be distinguished from sea lions by the presence of a dense under fur and their smaller size. Pelage color is generally uniform dark brown to dark gray on the dorsal surface with a grizzled appearance caused by the tips of guard hairs being pale or white (ibid).

Status and trends: Guadalupe fur seals belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae. These fur seals were harvested for their pelts in the 19th century but size of the population prior to the commercial harvests is unknown; estimates range from 20,000 to 100,000 animals (Carretta et al. 2014, and citations therein). The Guadalupe fur seal occurs in low numbers seasonally in California waters. The 1993 population estimate was about 7,408 animals, derived by multiplying the number of pups (counted and estimated) by a factor of 4.0 (Gallo 1994). The minimum size of the population in Mexico was estimated using the actual count of 3,028 hauled out seals. The most recent PBR was calculated at 91 Guadalupe fur seals (Carretta et al. 2014). However, these data are now outdated (older than eight years), as the last abundance survey occurred in 1993. The minimum population estimate should, therefore, be considered unknown and the PBR, consequently, cannot be determined (NMFS 2005b).

The state of California lists the Guadalupe fur seal as a fully protected mammal and it is listed also as a threatened species in the Fish and Game Commission California Code of Regulations. It is listed as a threatened species under the ESA, which automatically qualifies this as a "depleted" and "strategic" stock under the Marine Mammal Protection Act. There is insufficient information to determine whether the fishery mortality in Mexico exceeds the most recently calculated (now outdated) PBR for this stock. The total U.S. fishery mortality and serious injury for this stock is less than 10% of the prior PBR and, as the population is growing at about 13.7% per year (Caretta et al. 2014), is likely to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: Guadalupe fur seals pup and breed mainly at Isla Guadalupe, Mexico (Arnould 2009; Carretta et al. 2014 and citations therein). In 1997, a second rookery was discovered at Isla Benito del Este, Baja California and a pup was born at San Miguel Island, California. Individuals have stranded or been sighted as far north as central California, inside the Gulf of California, and as far south as Zihuatanejo, Mexico. The population is considered to be a single stock because all are recent descendants from one breeding colony at Isla Guadalupe, Mexico.

Behavior and life history: Definitive data are lacking on life history of Guadalupe fur seals but most species in the genus reach sexual maturity at 3-5 years of age; males also mature at about the same age but are unable to attain reproductive status (obtain a reproductive territory) until 7-10 years of age. Timing of pupping is variable for the genus but for Guadalupe fur seals it is June-July. Southern fur seals, including the Guadalupe fur seal, feed on a variety of prey including fishes, cephalopods and crustaceans, depending on prey abundance and location. Most southern fur seals forage in upwelling zones, oceanic fronts, or continental shelf-edge regions (Arnould 2009). Specific foraging and dive information is not known for the Guadalupe fur seal, but other species in this genus forage mainly in the surface mixed layer (<50-60 m) at night (Arnould 2009).

Acoustics and hearing: Like other pinnipeds, these fur seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4-1).

4.2.4 Northern Fur Seal (*Callorhinus ursinus*) California and Eastern Pacific Stocks

Description: The northern fur seal is a moderate sized pinniped and shows a marked difference in size with males two to three times larger than females. Northern fur seal males weigh 200-250 kg and are up to 1.9 m long; females weigh up to 45 kg and are 1.3 m long. Pups are black, weigh about 10 kg and are about 0.6 m long at birth (Gentry 2009). The under-fur is brown, very dense, and covered by coarser guard hair that in males varies from black to reddish, with a mane over the shoulders that is often a different color; females are typically brown to gray and lack the mane.

Status and trends: Fur seals belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae. The genus *Callorhinus* contains one species, the northern fur seal, *C. ursinus*. Northern fur seals are divided into two stocks in U.S. waters: Eastern Pacific stock (Pribilof Islands and Bogoslof Island) and California stock (includes San Miguel Island and Farallon Islands). The Eastern Pacific stock has declined by about 60% in recent decades from a historical high of over 2 million in the 1970s to an estimated 653,171 based on pup counts from 2007 and 2008 (Allen and Angliss 2014). The Eastern Pacific stock of northern fur seal was designated as “depleted” pursuant to the Marine Mammal Protection Act on 17 June 1988 because it declined to less than 50 percent of levels observed in the late 1950s and there was no compelling evidence that the northern fur seal carrying capacity of the Bering Sea had changed substantially since the late 1950s (NMFS 2007). A recent best population estimate for this stock, based on 2008-2011pup counts, is 639,545. The minimum estimate is 541,317 fur seals and the calculated PBR is 11,638 (Allen and Angliss 2014). Estimated minimum annual average mortality in observed commercial fisheries is 4.6 fur seals, which is less than ten percent of PBR for this stock, so can be considered insignificant and approaching a zero mortality and serious injury rate. Estimated total annual human-caused mortality and serious injury is 471 fur seals (commercial fisheries [4.6], unknown fisheries [1], Alaska Native subsistence harvest [463], research activities [0.4], and marine debris [2]). Because this stock is designated as “depleted” under the MMPA, it is classified as a “strategic” stock (Allen and Angliss 2014).

The San Miguel Island population originated from colonization by individuals from the Eastern Pacific stock during the 1950s or early 1960s (DeLong 1982). The colony has increased steadily, since its discovery in 1968, except for severe declines in 1983 and 1998 associated with El Niño Southern Oscillation events in 1982-1983 and 1997-1998 (DeLong and Antonelis 1991). The population estimate for the California stock (12,844) incorporates estimates from San Miguel Island (12,368) and the Farrallon Islands (476). The minimum population estimates are 6,722 for the California stock and 6,431 and 291 for San Miguel Island and the Farallons, respectively (Carretta et al. 2014). The calculated PBR for the California stock is 403 northern fur seals per year. There were no observer reports of northern fur seal deaths in any observed fishery along the west coast of the continental U.S. in 2007-2011 (Carretta et al. 2014). Stranding records for fishery related mortalities result in a mean annual mortality of 0.4 northern fur seals. Non-fishery related stranding records result in a mean annual human related mortality of 1.2 animals from this stock between 2007 and 2011. The mean annual research-related mortality of northern fur seals from 2007 to 2011 is 1.0 animal. The minimum annual human-caused mortality and serious injury is 2.6, which is well below PBR. The minimum annual fishery-related mortality and serious injury level is 0.4, and, thus, appears to be approaching a zero mortality and serious injury rate (Carretta et al. 2014). The California stock is not designated as “depleted” under the MMPA or listed as “threatened” or “endangered” under the ESA.

Distribution and habitat preferences: NMFS (2007) summarized northern fur seal distribution. They are endemic to the North Pacific Ocean. During the winter the southern limit of their range extends across the Pacific Ocean from southern California to the Okhotsk Sea and Honshu Island, Japan. In the spring most northern fur seals migrate north to breeding colonies in the Bering Sea. The largest breeding colonies are located on St. Paul and St. George islands in the Pribilof Islands and compose approximately 74 percent of the worldwide fur seal population. Other breeding colonies are located in the Commander Islands (Russia) in the western Bering Sea and on Robben Island (Russia) in the Okhotsk Sea that compose approximately 15 and 9 percent of the population, respectively. Small breeding colonies are also located on the Kuril Islands in the western North Pacific, Bogoslof Island in the central Aleutian Islands, and on San Miguel Island off the southern California coast. The subpolar continental shelf and shelf break from the Bering Sea to California are feeding grounds while fur seals are at sea. Highest fur seal densities in the open ocean occur in association with major oceanographic frontal features such as sea mounts, valleys, canyons and along the continental shelf break (NMFS 2007). Fur seals from San Miguel Island may also spend their winter months feeding at sea in the eastern North Pacific Ocean. Northern fur seals are primarily pelagic in the winter months, but occasionally haul-out onto land for brief periods.

Behavior and life history: Northern fur seals are the most pelagic of pinnipeds with females spending all but 35 days per year at sea and males 45 days (Gentry 2009). From November to March they remain north of about 35^{o} N latitude without coming ashore. In March and April they gather along continental shelf breaks and begin to migrate to their respective breeding islands (Gentry 2009). Males come ashore and acquire breeding territories in late May and June and most pups are born in July, nursed for about 4 months and weaned in October or November. They are a highly migratory species and typically return to their natal sites to breed.

Northern fur seals prey primarily on schooling fishes and gonatid squids, although the species consumed vary with location and season (Sinclair et al. 1996). Northern fur seals collected in continental shelf waters off the California and Washington coast between 1958 and 1972 fed primarily on fishes, while those collected beyond the shelf fed primarily on squids (Kajimura 1984). Adult female northern fur seals breeding on San Miguel Island fed on Pacific whiting, northern anchovy, juvenile rockfishes, and several squid species in the oceanic zone northwest of the island. Pacific herring was consumed by fur seals in neritic areas off the coast of Washington during December-January and May-June. Rockfishes, northern anchovy, and squids were more prominent in fur seal stomachs off Washington during February and March (NMFS 2007). Dive behavior of northern fur seals is well studied and shows that females from the Pribilof Islands often dive to 200 m or more for at least 5-6 minutes with some to 11 minutes. Similar foraging behavior has been documented for fur seals foraging from San Miguel Island, CA (Gentry 2009).

Acoustics and hearing: Fur seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4-1).

4.2.5 Harbor Seal (*Phoca vitulina richardsi*) California, Oregon and Washington Coastal, and Inland Washington Waters Stocks

Description: Harbor seals are relatively small pinnipeds compared to sea lions and elephant seals. Males tend to be slightly larger than females. Both sexes weigh about 90-120 kg but can be as large as 180 kg and can be 1.2-1.8 m long (Burns 2009). They are covered with short, stiff hair with variable color pattern and two basic color phases. Background color ranges from yellowish (light phase) to black (dark phase), which is then covered with dark spots, and light rings (Burns 2009).

Status and trends: Harbor seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. There are two presently recognized subspecies of harbor seal in the Pacific; *P.v. stejnegeri* in the western North Pacific, near Japan, and *P.v. richardsi* in the eastern North Pacific (Carretta et al. 2014). Three harbor seal stocks are recognized within the *P. v. richardsi* subspecies designation, including the California stock, outer coast of Oregon and Washington coastal stock, and Washington inland waters stock (Carretta et al. 2014, Lamont et al. 1996). The California stock is estimated to number 30,968 seals with a minimum population estimate of 27,348 seals and a calculated PBR of 1,641California harbor seals per year (Carretta et al. 2015). The Oregon/Washington coastal stock was estimated to number 24,732 harbor seals over ten years ago but because the most recent abundance estimate is >8 years old, there is no current estimate of abundance and consequently no estimate of PBR. Similarly, the number of seals in the Washington inland waters stock was estimated to be 14,612 but because the population estimates are >8 years old there is currently no estimate for the minimum population size and consequently no estimate of PBR (Carretta et al. 2013).

Harbor seals are not considered to be “depleted” under the MMPA or listed as “threatened” or “endangered” under the ESA. Based on currently available data, the level of human-caused mortality and serious injury (31, 10.6, and 13.4 per year for the California stock (2005-2009), Oregon/Washington coastal stock (2007-2011), and Washington inland waters stocks (2007-2011), respectively) does not exceed the calculated PBR for the California stock and is unknown, but unlikely exceeds, PBR for the others. Therefore, none of the three stocks of harbor seals are classified as a “strategic” stock. The minimum estimated fishery mortality and serious injury (30, 8.2, 4.0 per year for the California stock, Oregon/Washington coastal stock, and Washington inland waters stocks, respectively) is less than 10 percent of the calculated PBR for the California stock and is unknown, but likely less than 10 percent of PBR for the other stocks and, therefore, appears to be insignificant and approaching zero mortality and serious injury rate (Carretta et al. 2014).

Distribution and habitat preferences: The species is widespread in temperate and arctic waters of the northern hemisphere of both the Atlantic and Pacific Oceans; it is the most widespread of any pinniped. It occurs year-round in Washington. They occur principally in the near shore zone. Harbor seals use hundreds of sites to rest or haulout along the coast and inland waters, including intertidal sand bars and mudflats in estuaries, intertidal rocks and reefs, sandy, cobble, and rocky beaches, islands, log-booms, docks, and floats in all marine areas of the state. They are seen in low numbers in the Columbia River as far as Bonneville Dam (Stansell at al 2012). Group sizes typically range from small numbers of animals on some intertidal rocks to several thousand animals found seasonally in coastal estuaries (Burns 2009).

Behavior and life history: Harbor seals are considered a non-migratory species, breeding and feeding in the same area throughout the year. They give birth on shore and nurse their single pup for 4 to 5 weeks. After the pups are weaned, they disperse widely in search of food. Pupping seasons vary by geographic region, with pups born in coastal estuaries from mid-April through June; Olympic Peninsula coast from May through July; San Juan Islands and eastern bays of Puget Sound from June through August; southern Puget Sound from mid-July through September; and Hood Canal from August through January (Jeffries et al. 2000). Breeding occurs in the water shortly after the pups are weaned. Common prey include sole, flounder, sculpins, hake, cod, herring, squids, octopus, and, to a lesser degree, salmon (Orr et al. 2004). Harbor seals can dive to over 400 m and stay submerged over 20 minutes, but the average depth is less than 100 m and about 2 minutes in duration (Eguchi and Harvey 2005).

Acoustics and hearing: Harbor seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from 25 Hz to 4 kHz (DON 2008a) (Table 4-1).

4.2.6 Northern Elephant Seal (*Mirounga angustirostris*) California Breeding Stock

Description: Northern elephant seals are the largest pinniped in the California Current Ecosystem. The species is sexually dimorphic with males weighing about 1,800 kg with a length of 4.8 m; females weigh about 900 kg and are about 2.5 m in length (Hindell and Perrin 2009). Males have a large inflatable proboscis and a pronounced chest shield associated with fighting with other males on land to acquire females. Females lack the proboscis and chest shield (ibid). Both males and females are gray to brown in color.

Status and trends: Northern elephant seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. Elephant seal population size is typically estimated by counting the number of pups produced and multiplying by the inverse of the expected ratio of pups to total animals. Based on the estimated 40,684 pups born in California in 2010 and a 4.4 multiplier, the California stock was approximately 179,000 in 2010, with a minimum population estimate of 81,368 elephant seals (Carretta et al. 2015). The California population is slowly increasing. Elephant seals are not listed as either “threatened” or “endangered” under the ESA or by WA State nor designated as “depleted” under the MMPA. The calculated PBR for this stock is 4,882 (Carretta et al. 2015). Because their annual human-caused mortality (≥8.8) is less than the PBR, they are not considered a “strategic” stock under the MMPA. The average rate of incidental fishery mortality (≥4.0) for this stock appears to be less than 10% of the PBR; therefore, the total fishery mortality appears to be insignificant and approaching a zero mortality and serious injury rate.

Distribution and habitat preferences: After the breeding season, immature and adult male northern elephant seals move northward to feed from Baja California to northern Vancouver Island and far offshore of the Gulf of Alaska and Aleutian Islands; adult females typically feed in the western North Pacific (Carretta et al. 2014). Northern elephant seals breed at about 15 colonies on the mainland and on islands off the California coast from the Farallon Islands, CA, south to islands off Mexico during winter. When not on the islands to breed or molt they tend to occur in deep offshore waters from central California north to the Aleutian Islands and west to Japan. Females tend to go farther northwest and males farther north (Hindell and Perrin 2009). However it is not uncommon to see male and female northern elephant seals hauled out on land alongside harbor seals, California and Steller sea lions, and northern fur seals throughout the North Pacific.

Behavior and life history: Adult males haulout onto deserted beaches in November/December; adult females arrive soon thereafter and a single pup is born about 2-5 days later. Elephant seals are highly polygynous with large dominant males presiding over large aggregations of females, known as harems consisting of up to 100 animals (Hindell and Perrin 2009). Males feed near the eastern Aleutian Islands and in the Gulf of Alaska, and females typically feed south of 45^{o} N latitude. Elephant seals prey on deepwater and bottom dwelling organisms, including fishes, squids, crabs, and octopus. They are extraordinary divers with some dive depths exceeding 1500 m and 120 minutes (Hindell and Perrin 2009).

Acoustics and hearing: Like other pinnipeds, elephant seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4-1).

5.0 TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

The promulgation of regulations and subsequent issuance of annual Letters of Authorization (LOA) for the incidental taking of marine mammals is requested pursuant to Section 101 (a) (5) (A) of the Marine Mammal Protection Act (MMPA).

The term “take,” as defined in Section 3 (16 U.S. Code [U.S.C.] 1362) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, which provided two levels of “harassment,” “Level A” (non-serious injury) and “Level B” (disturbance).

The NWFSC requests the promulgation of regulations and subsequent issuance of LOAs to authorize potential lethal and non-lethal incidental takes during its planned scientific operations. The requested numbers of authorized lethal and serious injury[1] takes and non-serious injury “Level A” and “Level B” harassment takes per year are discussed in Section 6. Although serious injury or mortality are rare during Center research activities, the NWFSC requests that the LOA authorize a small number of incidental, non-intentional, injurious or lethal takes of marine mammals in the event that they might occur, and in spite of the monitoring and mitigation efforts described in Sections 11, 13, and 14.

Potential gear related takes: NWFSC surveys involve the use of gear that has the potential to take marine mammals, including bottom, midwater, and surface trawls, purse seine gear, tangle net gear, and hook-and-line gear (including rod and reel, troll, and longline deployments) in the CCRA, PSRA, and LCRRA (e.g., see Table 6-1). These takes may occur in two forms: (1) take by accidental entanglement that may cause mortality and serious injury, and (2) take by accidental entanglement that may cause non-serious injury (“Level A” harassment take). To date all but two serious injury and mortality takes occurred in surface trawls and most were taken during the Juvenile Salmon PNW Coastal Survey (33). The three other surveys with reported marine mammal takes are the Northern Juvenile Rockfish Survey (2 takes in a modified-Cobb mid-water trawl), the Skagit Bay Juvenile Salmon Survey (1), and the PNW Piscine Predator and Forage Fish Survey (6). This last survey is no longer conducted.

“Level B” harassment takes: These takes may occur as the result of active acoustic gear used during survey operations in the CCRA by the NWFSC. The ‘take’ may be manifested as a temporary threshold shift (Southall et al. 2007) within the zone of audibility where the received levels of sound exposure are high enough that a marine mammal can hear it, or in the zone of responsiveness where the received level is such that the animal responds by causing behavioral modifications (Holt 2008). No hearing loss or physiological damage (e.g., permanent threshold shift, Southall et al. 2007) is expected to occur to marine mammals by the acoustic gear during NWFSC surveys in the CCRA (see more detailed discussion in sections 6.2 and 7.2). Level B harassment take may also occur if fishing operations temporarily disrupt feeding or other natural behaviors (e.g., migration) of marine mammals. For example, one might not see marine mammals in an area, and the noise/activity caused by the deployment of trawl gear may cause the animals to move away from an area temporarily.

Level B harassment takes also may occur to three species of pinnipeds within the PSRA and LCRRA due to the physical presence and passage of researchers for a small set of research activities. NWFSC researchers are very aware of this situation and take precautions to minimize the frequency and scope of potential disturbances, including choosing travel routes as far away from hauled out pinnipeds as possible and moving sample site locations to avoid consistent haulout areas. However, there are many narrow channels among the islands of Puget Sound and the LCRRA where the options for vessel traffic are limited. Combined with the fact that pinnipeds may haul out in new locations on a regular basis, it is

[1] NMFS interprets the regulatory definition of serious injury (i.e., “any injury that will likely result in mortality”) as any injury that is “more likely than not” to result in mortality, or any injury that presents a greater than 50 percent chance of death to a marine mammal. Thus, the definition does not require that all such injured animals actually die, but rather requires only that the animal is more likely than not to die. Further, an injury must directly contribute to the death or likely death of the animal to be classified as a serious injury.

essentially impossible for researchers to completely avoid disturbing pinnipeds as they move throught the region.

NWFSC fisheries research interacts with two species of pinnipeds in the LCRRA through active deterrence of “nuisance animals.” Visual and acoustic deterrence devices and techniques are occasionally used to dissuade pinnipeds attempting to enter or remove fish from research gear during the Pair Trawl Columbia River Juvenile Salmon Survey and the Migratory Behavior of Adult Salmon Survey. NWFSC fisheries research related activities used to dissuade pinnipeds include close approach to animals in the water near gear, aerial pyrotechnics (poppers and screamers), and, as a last resort, underwater detonation of seal bombs. Since these types of intentional takes are exempted under MMPA sections 101(a)(4)(A)(iv) and 109(h)(1)(C) (B. Norberg WCRO PRD, pers. comm.), no additional takes are requested for these types of activities.

6.0 THE NUMBER OF MARINE MAMMALS THAT MAY BE TAKEN BY EACH TYPE OF TAKING, AND THE NUMBER OF TIMES SUCH TAKINGS BY EACH TYPE OF TAKING ARE LIKELY TO OCCUR

6.1 Estimated Number of Potential Marine Mammal Takes by Mortality/Serious Injury, or by Non-Serious 'Level A' Harassment and Derivation of the Number of Potential Takes

6.1.1 Introduction

As stated in the response to Question 5 above, potential take during NWFSC surveys using surface, bottom and mid-water trawl nets may occur in two forms: (1) take by accidental entanglement that may cause mortality and serious injury, and (2) take by accidental entanglement that may cause non-serious injury ("Level A" harassment take). The surveys using these nets are conducted to assess coastal pelagic species, juvenile salmon, and juvenile rockfish in the CCRA, among other research purposes. Incidental takes resulting in mortality and serious injury and "Level A" harassment may also occur using purse seine gear and similar tangle net gear within the LCRRA. Sampling with rod and reel gear, trolling, and longline gear occurs in waters of the CCRA and a limited basis within Puget Sound. No marine mammal takes have occurred in past NWFSC research using these gears, although they are possible based on analogous takes of marine mammals in commercial and recreational fisheries.

The justification for potential take of marine mammal species and the estimated mortalities and injuries is discussed below.

6.1.2 Use of Historical Interactions as a Basis for Take Estimates

It was anticipated that all species that interacted with NWFSC survey gear historically could potentially be taken in the future. For the duration of the regulations, we estimated the numbers of marine mammals that may be caught during NWFSC surveys based on historic interaction data for a species. Historical interactions with marine mammals during NWFSC surveys (Table 6-1) were entered into NMFS Protected Species Incidental Take (PSIT) database, a real-time internal monitoring tool for reporting NMFS fisheries research interactions with all marine mammals.

The NWFSC considered all historic marine mammal interactions available since 1999 to calculate the total take request over the five-year authorization period. The discussion that follows describes how NWFSC estimated potential encounters with survey gear based on historical interactions during 1999-2014 in trawl nets. Historical data was used to determine the average takes per year and the likelihood of taking a particular marine mammal. For species that have not been caught in NWFSC research gear in the past, and for which there is a reasonable chance that they may be taken in the future, the methodology for estimating take requests for these species are explained in more detail in section 6.1.4.

Table 6-1 NWFSC Historic Takes of Marine Mammals

Survey Name	Marine Mammals Taken	Gear Type	Date (Time) Taken	Number Killed	Number Released Alive[1]	Total Taken
2014						
Juvenile Salmon PNW Coastal Survey	Pacific white-sided dolphin	Nordic 264 Surface Trawl	21 June (15:46)	6	0	6
2012						

Survey Name	Marine Mammals Taken	Gear Type	Date (Time) Taken	Number Killed	Number Released Alive[1]	Total Taken
Juvenile Salmon PNW Coastal Survey	Pacific white-sided dolphin	Nordic 264 Surface Trawl	28 June (15:35)	3	0	3
2010						
Juvenile Salmon PNW Coastal Survey	Harbor seal	Nordic 264 Surface Trawl	24 May (08:44)	1	0	1
2009						
Northern Juvenile Rockfish Survey	California sea lion	Modified Cobb Mid-water Trawl	26 May (06:26)	1	1	2
Juvenile Salmon PNW Coastal Survey	Unidentified porpoise or dolphin[2]	Nordic 264 Surface Trawl	23 May (14:48)	2	0	2
Skagit Bay Juvenile Salmon Survey	Harbor seal (OR-WA Coastal stock)	Nordic 264 Surface Trawl	16 May (10:50)	0	1	1
2007						
Juvenile Salmon PNW Coastal Survey	California sea lion	Nordic 264 Surface Trawl	28 September (08:15)	1	0	1
2006						
Predator and Forage Fish Survey[3]	Pacific white-sided dolphin	Nordic 264 Surface Trawl	28 August (05:00)	2	0	2
Predator and Forage Fish Survey[3]	Pacific white-sided dolphin	Nordic 264 Surface Trawl	1 June (05:35)	3	0	3
2005						
Juvenile Salmon PNW Coastal Survey	Pacific white-sided dolphin	Nordic 264 Surface Trawl	18 June (16:30)	3	0	3
2003						
Juvenile Salmon PNW Coastal Survey	Pacific white-sided dolphin	Nordic 264 Surface Trawl	25 June	1	0	1
Juvenile Salmon PNW Coastal Survey	Harbor seal	Nordic 264 Surface Trawl	30 June	1	0	1
Juvenile Salmon PNW Coastal Survey	Pacific white-sided dolphin	Nordic 264 Surface Trawl	30 June (20:24)	2	0	2
2002						
Juvenile Salmon PNW Coastal Survey	Steller sea lion	Nordic 264 Surface Trawl	22 September	1	0	1

Survey Name	Marine Mammals Taken	Gear Type	Date (Time) Taken	Number Killed	Number Released Alive[1]	Total Taken
Juvenile Salmon PNW Coastal Survey	Steller sea lion	Nordic 264 Surface Trawl	23 September	1	0	1
Juvenile Salmon PNW Coastal Survey	Steller sea lion	Nordic 264 Surface Trawl	24 September (17:56)	2	0	2
2001						
: Predator and Forage Fish Survey[3]	California sea lion	Nordic 264 Surface Trawl	19 July	1	0	1
2000						
Juvenile Salmon PNW Coastal Survey	Northern fur seal	Nordic 264 Surface Trawl	18 May	1	0	1
1999						
Juvenile Salmon PNW Coastal Survey	Pacific white-sided dolphin	Nordic 264 Surface Trawl	24 May (21:36)	4	0	4
Juvenile Salmon PNW Coastal Survey	Steller sea lion	Nordic 264 Surface Trawl	29 September (12:35)	1	0	1
Juvenile Salmon PNW Coastal Survey	Steller sea lion	Nordic 264 Surface Trawl	1 October (06:12)	3	0	3
Total				**40**	**2**	**42**

1. Serious injury determinations were not previously made for animals released alive, but will be part of standard protocols for released animals after such incidental takes are authorized and will be reported in Stock Assessment Reports.
2. The unidentified porpoises/dolphins were released from gear in unknown condition, so were assigned to mortality/serious injury status.
3. Survey discontinued.

6.1.3 Historical Interaction: Summary of Potential Trawl Survey Efforts

Marine mammals have the potential to be caught in numerous gear types used by the Center but have been caught only in Nordic 264 surface trawl and modified Cobb trawl nets historically during Center fisheries research. Marine mammals have the potential to be caught in surface, mid-water, and bottom trawl nets.

Nordic 264 surface trawl nets are used in the juvenile salmon surveys from La Push, WA, to Newport, OR, annually from May/June and September. The tows are conducted near the surface down to approximately 30 m deep using a charter vessel (Table 1-1). In addition, mid-water and bottom trawl nets are used for an assortment of surveys including the hake acoustic survey, groundfish bottom trawl survey and a variety of other surveys throughout the year in the CCRA and PSRA. These nets are used during daytime and nighttime trawls with tows at the target depth lasting for approximately 30 minutes. In total, these trawl surveys deploy over 2,270 tows per year (Table 1-1). The NWFSC predicts that about the same number of tows will be deployed using these nets over the duration of the five-year authorization period. Since 1999, Nordic 264 surface trawl nets captured 40 marine mammals and modified Cobb trawls caught two. Two marine mammals—one in each net type--were released alive; the remainder were known or presumed mortalities (Table 6-1). Most interactions (n=33) occurred in Nordic 264 surface trawl nets during the Juvenile Salmon PNW Coastal Survey.

Since 1999, species historically caught in these trawl nets include Pacific white-sided dolphins (n =24), northern fur seal (n =1), Steller sea lion (n=8), California sea lions (n=4; 1 released alive), harbor seal (n=3; 1 released alive), and unidentified porpoise or dolphins (n=2). Given the timing and geographic scope of its trawl surveys, the NWFSC believes it could take any age class of marine mammal for which it estimates potential take. Pacific white-sided dolphins calve during May-September (Section 4.1.3) so animals caught during this period may be part of the California-Oregon-Washington stock and actively engaged in breeding activities. California sea lions give birth and breed at California Channel Islands during May-June (section 4.2.1) so adult females caught in close proximity to the Center's research locations during this period could be pregnant or nursing a yearling. Males could be of breeding age and participate in the breeding population. Similarly harbor seals pup and breed during May-September throughout the region and animals caught may be part of the breeding population (section 4.2.5). In addition to these species which NWFSC has historically captured, other species NWFSC requests to take in the course of this research have similar distributions, life histories and/or vulnerabilities to these gears, so it follows that multiple age classes of these species could be susceptible to take.

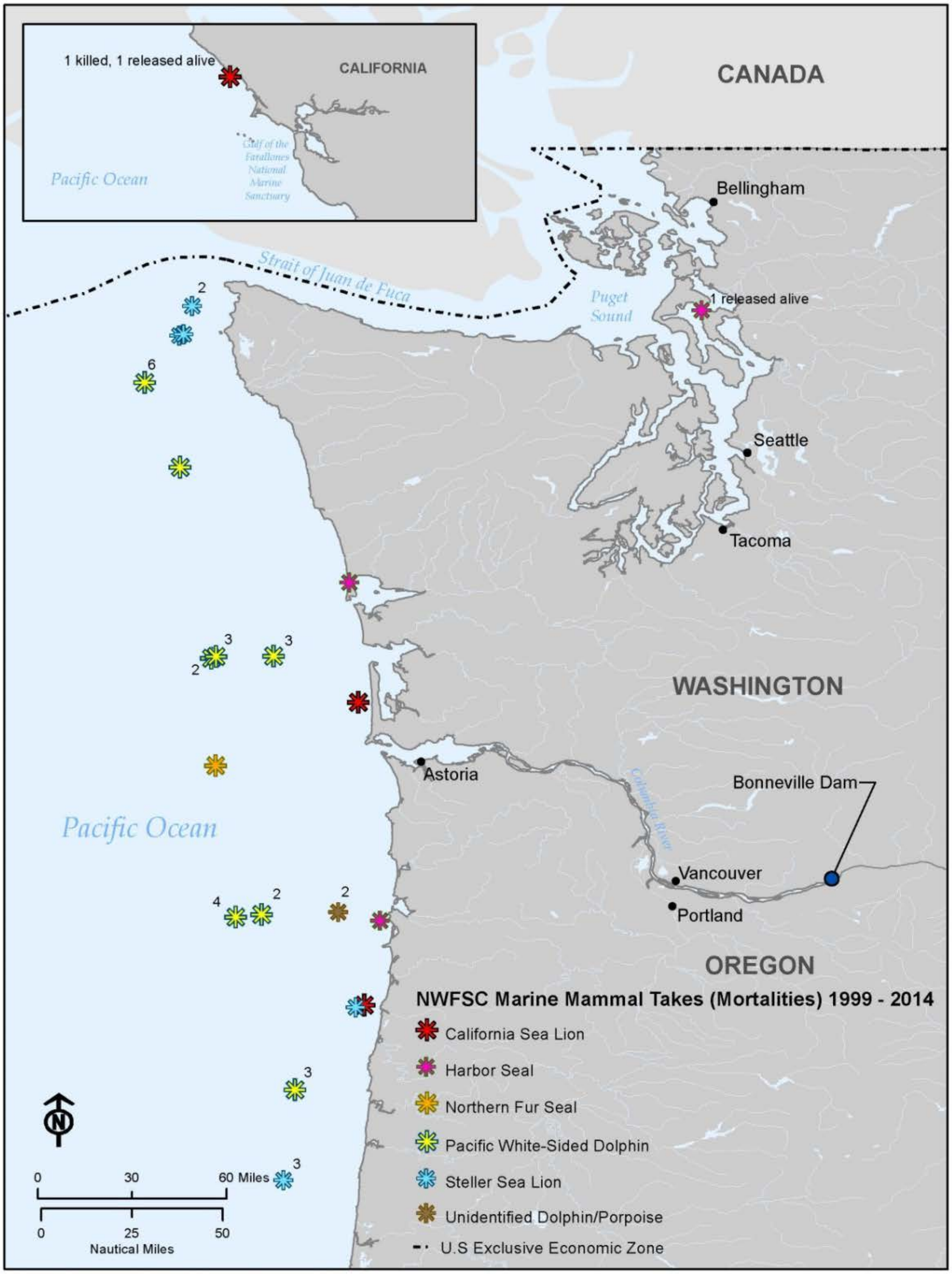

Figure 6-1 Location of Marine Mammal Takes During NWFSC Research from 1999-2014

6.1.4 Approach for Estimating Takes of Species Captured Historically

Historic NWFSC gear interactions with marine mammals have occurred principally in the CCRA, with just one take in the PSRA and no Level A, mortality or serious injury takes in the LCRRA.

The NWFSC take estimates are based on historical marine mammal species interactions during 1999-2014, which includes some inter-annual variability in marine mammal interactions during that time period, possibly due to changing marine mammal densities and distributions and dynamic oceanographic conditions. With the exception of Pacific white-sided dolphins (see below), the NWFSC uses the calculated average annual numbers of takes for each species that occurred in the past 15 years (1999-2014) and "rounds up" this annual average to the next highest whole number of animals. Since the LOA application requests takes for a five-year period, this intentionally inflated annual average is multiplied by five to produce an estimate higher than the historic average take for each species that has been taken incidentally during NWFSC research. For example, if a species interacted with NWFSC surface trawl gear 0.2 times per year, on average, this number was rounded up to one and then multiplied by five to determine a take request of five for the duration of the five-year authorization period. This methodology has been used in order to ensure accounting for a precautionary amount of potential take in the future. This method helps to account for the fluctuations in inter-annual variability observed during that time period.

Because there is a very fine line between the two take categories (mortality and serious injury and Level A harassment) and insufficient data exist to understand the circumstances that lead to one event or the other, the NWFSC believes it would be unjustified to estimate potential takes in each category based only on historic interactions in that category; a Level A harassment take could easily have been a serious injury or mortality under a slightly different set of circumstances and vice versa. The NWFSC incidental take request is therefore described in terms of the combined Level A harassment, mortality, and serious injury takes for the five-year authorization period (Table 6-2).

Pacific white-sided dolphins are a special case because they are the most frequently caught marine mammal species in NWFSC fisheries research surveys and most of these takes involved more than one animal in a given trawl. Between 1999 and 2014, all 24 Pacific white-sided dolphins captured in NWFSC fisheries research surveys were lethal takes. There were 19 Pacific white-sided dolphins taken in the Juvenile Salmon PNW Coastal Survey and five taken in the PNW Piscine Predator and Forage Fish Survey, all within the CCRA. The maximum number of Pacific white-sided dolphins captured in a single set was six during a 2014 Juvenile Salmon PNW Coastal Survey. Given the high abundance of Pacific white-sided dolphins in the CCRA and the past frequency of multiple takes in a single set, the average-based approach does not represent a conservative approach for estimating potential take levels. Instead, for this species only, the NWFSC assumes that the worst historical record of takes in a given set could occur every year over the five-year authorization period. Therefore, based on this "worst-case" approach, the NWFSC requests the potential take of six Pacific white-sided dolphins per year in the CCRA, for a maximum take of 30 Pacific white-sided dolphins over the five-year authorization period in trawl gear (Table 6-2).

For California sea lion, Steller sea lion, harbor seal, and northern fur seal the "rounded up average" take in the CCRA is one animal for each species, which translates into a combined mortality, serious injury, and Level A harassment take request of five California sea lions (all stocks combined), five Steller sea lions (eastern DPS), five harbor seals (all stocks combined), and five northern fur seals (two stocks combined) over the five-year authorization period in trawl gear in the CCRA (Table 6-2). In addition, one historic take of a harbor seal in the PSRA rounds up to an average of one take per year and a total of five over the five-year authorization period in trawl gear in the PSRA (Table 6-2)

Although the NWFSC take estimates for species captured historically are based on an average take during 1999-2014 (Pacific white-sided dolphin estimate being an exception), it should be emphasized that there is still an inherent level of uncertainty in estimating potential take both in terms of numbers and species of marine mammals that may actually be taken. Furthermore, mitigation measures have been developed and implemented subsequent to some of the years upon which the take estimates are based, which reduces the likelihood that these estimates would be exceeded. In addition, the NWFSC continues to invest significant resources in better understanding the factors that contribute to interactions and developing mitigation measures and evaluating its operations to minimize these occurrences in the future.

Table 6-2 Requested Incidental Marine Mammal Takes Based on Historical Takes in NWFSC Research Trawls

This table summarizes the NWFSC request for combined potential takes by Mortality and Serious Injury (M&SI) and Level A harassment for species that have been taken in NWFSC research trawls since 1999 (Table 6-1). The first number in each cell is the annual take requested and the following number in parenthesis is the total for the five-year authorization period.

Species	Requested M&SI and Level A Take Average per Year (Total for Five-year Period)	
	CCRA	PSRA
	Trawls	Trawls
Pacific white-sided dolphin	6 (30)	0
California sea lion	1 (5)	0
Steller sea lion (Eastern DPS)	1 (5)	0
Northern fur seal (two stocks)	1 (5)	0
Harbor seal	1 (5)	1 (5)

6.1.5 Approach for Estimating Takes of Species Analogous to Those Historically Taken by the NWFSC

In addition to those species the NWFSC has historically interacted with in trawl nets, the NWFSC believes it is appropriate to include estimates for future incidental takes of a number of species that have not been taken historically but inhabit the same areas and show similar types of behaviors and vulnerabilities to such gear as the "reference" species taken in the past. In short, while they have not been taken historically, there is some risk that they could be taken in the future. The NWFSC believes the potential for take of these other "analogous" species would be low and would occur rarely, if at all, based on lack of takes since 1999.

In analyzing the take of "analogous" species, NWFSC considered that their surveys are not limited to the waters of Oregon and Washington but extend into California (e.g., juvenile rockfish survey, groundfish and hook and line). Thus, we considered distribution of marine mammals over this entire area and not just in Oregon and Washington.

The approach outlined below reflects: (1) concern that some species with which we have not had historical interactions may interact with these gears, (2) acknowledgment of variation between sets, and (3) understanding that many marine mammals are not solitary, so in many cases if a set results in take, the take is likely to be greater than one animal particularly with trawl gear. The approach takes into account the possibility that additional species could interact with NWFSC surveys, while also reflecting that, absent significant range shifts or changes in habitat usage, such events would likely remain rare occurrences. Recognizing these uncertainties, additional mitigation measures may be implemented if take far exceeds the maximum number estimated per year, such that it appears that the total estimated take over the five-year authorization period may be exceeded. For example, the take of six Pacific white-sided dolphins in one Juvenile Salmon Survey in 2014 precipitated emergency rules for that survey to add marine mammal excluder devices (MMED) to the Nordic 264 trawl nets used in research. The NWFSC had been experimenting with the MMED for several years but it was not implemented on the survey previously because it had strong selectivity issues for some target fish species. The NWFSC continues to modify and test different configurations of the MMED to address the survey data issues but the MMED continues to be part of the gear protocols for that survey. Additional research will be necessary to calibrate catch levels in tows with the MMED compared to past tows that did not contain the excluder (i.e., to align the new catchability rates with historical data sets). The NWFSC will use high-resolution video cameras on tows made with and without the MMED both to evaluate effects of the MMED on catch and to determine if marine mammals enter the net undetected by observers and either escape on their own by swimming out of the net or through the MMED. Continued monitoring with video gear attached to the net and analyzing the results could be used to further modify the gear or survey protocols to reduce the risk of adverse interactions.

Historically, the NWFSC has not interacted with ESA-listed marine mammals. Further, the NWFSC is very concerned about the prospect of taking ESA-listed species, particularly the endangered southern resident stock of killer whales (SRKW), and it has worked extensively in developing sampling protocols that include mitigation measures designed to minimize the risk of taking these species and all marine mammals. However, for purposes of estimating potential take the NWFSC did not differentiate between ESA-listed species or other marine mammals. Marine mammal species, listed or not, deemed to have a similar vulnerability to entanglement/capture in trawl gear as species that have historically interacted with NWFSC trawl gear was the overriding factor in estimating potential takes.

The following take request justification is presented for each research area.

CCRA

To estimate the requested taking of analogous species, the NWFSC identified several species in the CCRA that we believed to have similar vulnerability to trawl gear as some historically taken species. A number of factors were taken into account to determine whether another species may have a similar vulnerability to certain types of gear as historically taken species (e.g., distribution, density, abundance, behavior, feeding ecology, travel in groups, commonly associated with other species historically taken, prior interactions with similar gear in the 2015 List of Fisheries, or reported interactions with other NMFS Fisheries Science Center surveys, etc.) In these particular instances, the NWFSC estimates the annual take of these analogous species to be equal to the maximum interactions per any given set of the reference species that was historically taken during 1999-2014 (Table 6-1).

The Pacific white-sided dolphin was used as the reference species for potential trawl interactions with other dolphins/porpoises. The dolphin/porpoise species that we concluded would have similar vulnerability to trawl gear in the CCRA based on the factors listed in the previous paragraph were: striped dolphins, Risso’s dolphin, and northern right whale dolphin. We considered these analogous species because we often find them in mixed species aggregations with Pacific white-sided dolphins and thus we expect them to behave similarly to the trawl, have similar range, distribution, and habitat. These species, like Pacific white-sided dolphins, are also abundant throughout our survey area. The maximum take of Pacific white-sided dolphins in any set since 1999 was six individuals. Using the maximum number of takes of Pacific white-sided dolphins as a baseline, the NWFSC requests a total of six potential takes (an average of 1.2 animals/year) in the CCRA over the five-year authorization period for each of the three species listed above (striped dolphin, Risso’s dolphin, and northern right whale dolphins) in trawl gear (Table 6-3).

The NWFSC has taken four species of pinnipeds in trawl surveys historically (northern fur seal, harbor seal, California sea lion, and Steller sea lion). We do not consider any other pinnipeds in the CCRA to be similar in their vulnerability to trawl gear. In particular, the Guadalupe fur seal is found far to the south of our surveys that extend into California and is not abundant. Although elephant seals are abundant in California, we opted not to request take of elephant seals primarily because they vacate coastal areas in early spring to migrate to feeding areas that are well offshore and generally north of our survey areas. Their migration from coastal areas in spring occurs before most of our surey effort occurs in waters off California.

PSRA

In the PSRA, the NWFSC has one historical take of a harbor seal in a surface trawl (released alive). Using harbor seals as a reference species for other pinnipeds, the NWFSC considers California sea lions and Steller sea lions to be analogous to harbor seals in their vulnerability to trawls in this area based upon the habitats they occupy, what they feed on, and seasonality. In particular, harbor seals and sea lions (both California and Steller) can often be found hauled out in the same area and all three species rely heavily on fish, especially salmon during some parts of the year. The maximum take of harbor seals in any set since 1999 was one individual. Using this as a reference baseline, the NWFSC requests one take each of California sea lion and eastern stock Steller sea lion in trawl gear in the PSRA over the five-year authorization period (Table 6-3).

LCRRA

The NWFSC has had no historical takes of pinnipeds or other marine mammals in any gear in the LCRRA. Therefore any take requests will be based upon commercial and recreation fisheries comparisons.

Table 6-3 Requested Incidental Marine Mammal Takes Based on Analogy to Species Taken Historically in NWFSC Research Trawls

This table summarizes the NWFSC request for combined potential takes by Mortality and Serious Injury (M&SI) and Level A harassment for species that are considered analogous (i.e., similar in vulnerability to take in the given research area) as species that have been taken in NWFSC research trawls since 1999 (Table 6-1). The first number in each cell is the annual take requested and the following number in parenthesis is the total for the five-year authorization period.

Species	Requested M&SI and Level A Take Average per Year (Total for Five-year Period)	
	CCRA	PSRA
	Trawls	Trawls
Risso's dolphin	1.2 (6)	0
Striped dolphin	1.2 (6)	0
Northern right-whale dolphin	1.2 (6)	0
California sea lion	0	0.2 (1)
Steller sea lion (Eastern DPS)	0	0.2 (1)

6.1.6 Approach for Estimating Takes of Species Analogous to those Taken in Commercial and Recreational Fisheries

In addition to species that are considered analogous to species that have been captured historically in NWFSC research gear, the NWFSC is requesting potential takes of several species based upon their incidental catch in commercial fisheries occurring in the NWFSC research areas (based on the 2015 List of Fisheries) using gears that are similar to those used in fisheries research. We reviewed the 2015 List of

Fisheries and identified commercial fisheries that used gear similar to ours. We did not consider frequency of use of the commercial gear or aspects of their spatial and temporal use. We examined the incidental capture of marine mammals by these commercial fisheries and focused on the species they captured as opposed to the abundance of each species. After making this comparison, the NWFSC considers several marine mammal species to have a reasonable chance of being caught in NWFSC research gear in the future. The NWFSC believes that any incidental takes would likely be rare occurrences based on their lack of historical captures in research gear, their behavioral and ecological characteristics which reduce the risk of incidental capture in research gear, and mitigation measures in place to reduce the risk of incidental capture.

CCRA

In the CCRA, the NWFSC requests one take each over the five-year authorization period for harbor porpoise (across several stocks), Dall's porpoise, short-beaked common dolphin, long-beaked common dolphin, and bottlenose dolphin (two stocks) in trawl gear based on similar vulnerability (and capture) in commercial fisheries (Table 6-4). Although there are no historical research takes of any of these species, they are caught incidentally in commercial fisheries using gears similar to our trawls. We note that harbor porpoise, Dall's porpoise, and short and long beaked dolphin are all abundant in the CCRA and are often observed by scientists during research cruises. Although bottlenose dolphins are not abundant in Washington and Oregon (in fact they are rare), they are abundant off of California where we conduct several trawl surveys (e.g., juvenile rockfish survey). We are requesting no other take of any marine mammal species in trawl gear in the CCRA (including pinnipeds) based upon comparisons with commercial fisheries.

In the CCRA, the only other net that is used other than trawl nets are purse seines and there is only limited use of this net. Purse seines have a low risk of marine mammal takes based on the lack of historical takes in these gear types, the limited research effort conducted with these gears, and the mitigation measures in place. The NWFSC believes there is no risk of taking whale species (no purse seine fisheries in the CCRA have records of whale takes in the 2015 List of Fisheries) and very low risk of pinniped take for several reasons, although commercial seiners have caught California sea lions and harbor seals in the CCRA. First, NWFSC scientists have witnessed numerous times that pinnipeds are adept at jumping into and out of the net without getting entangled. In particular, they easily swim over the corks into the net to grab fish captured by the seine and swim back over the corks. Second, research nets are typically smaller than many commercial seines which reduces the risk of pinniped take as does the use of mitigation protocols such as the move-on rule (Section 11.2). Third, the amount of research with purse seine gear is very limited, as opposed to use of this gear type in the LCRRA (see below).

The NWFSC believes the species most at risk of take in research purse seines in the CCRA would be dolphins and porpoises based on documented capture of short-beaked and long-beaked common dolphins in commercial purse seine gear along the West Coast (2015 List of Fisheries). Because the NWFSC purse seine is used only in Oregon and Washington and in more near-coastal areas (within 10 nautical miles of shore), the primary animals that the NWFSC believes are at risk of take are Pacific white-sided dolphin, harbor porpoise, Dall's porpoise, Risso's dolphin, northern right whale dolphin, and short-beaked common dolphin. We have not included long-beaked common dolphins because they are much rarer in Oregon and Washington where the purse seine survey is conducted. We considered these species to be at risk because several are found in mixed schools (e.g., Pacific white-sided dolphins, northern right whale dolphins, Risso's dolphins, and striped dolphins) and all these dolphin species are found in the coastal areas of Washington and Oregon as well. Therefore, considering the near-coastal distribution and habitat use of these dolphin and porpoise species, the fact that some species have been caught in commercial purse seines, and the fact a number of the species occur in mixed schools which suggests they could be vulnerable to capture in the same gear, the NWFSC requests a take of one animal each of the following species over the five-year authorization period: Pacific white-sided dolphins, Dall's porpoise, harbor porpoise, northern right whale dolphin, Risso's dolphin, and short-beaked common dolphins. The

NWFSC is not requesting take of striped dolphins, long-beaked dolphins, or bottlenose dolphins in purse seine gear because they are rare in northern Oregon and Washington, where the NWFSC purse seining occurs.

The NWFSC uses several hook-and-line types of research gear in the CCRA (including California, Oregon, and Washington). These gear arrangements include demersal longlines, rod and reel, and trolling deployments. None of these different types of hook-and-line arrangements have had any past incidental takes. However, information obtained from commercial and recreational fisheries and other researchers working in the CCRA (e.g., the SWFSC) suggests that some marine mammal species could be vulnerable to take by hook-and-line gears in the CCRA.

While the NWFSC has not historically interacted with large whales or other cetaceans in its hook-and-line gear, it is well documented that some of these species are taken in commercial fisheries using hook-and-line gears (2015 List of Fisheries). The NWFSC also used other information to help make an informed decision on the probability of specific cetacean and large whale interactions with longline gear (e.g., relative survey effort, survey location, similarity in gear type, animal behavior, and lack of NWFSC interactions with longline gear, etc.). Therefore there are several species that have been shown to interact with commercial longline fisheries, large whales for example, but for which the NWFSC is not requesting take. Although large whale species could become entangled in longline gear in particular, the NWFSC considers the probability of interaction with research hook-and-line gear to be extremely low given a much lower level of survey effort and shorter duration sets relative to that of commercial fisheries. Data on commercial fishing effort (i.e., total length of longlines, numbers of hooks deployed, buoy lines, and soak times) are not publically available and we know of no other proxies for effort that could be compared to our research effort. However, based on the amount of fish caught by commercial fisheries versus NWFSC fisheries research (Section 9), the “footprint” of research effort compared to commercial fisheries is very small.

There were several smaller species of cetaceans that were identified as having a higher probability of interaction with NWFSC hook-and-line gear based on the factors outlined previously. Since these interactions would probably be rare occurrences and groups of marine mammals (as opposed to individuals) are less likely to be taken on longlines or other hook-and-line gears (relative to trawls), the NWFSC requests only one potential take each of the following delphinid species (all stocks included) for the five-year authorization period: Risso’s dolphin, bottlenose dolphin, striped dolphin, short-beaked common dolphin, long-beaked common dolphin, and short-finned pilot whale. Additionally, the NWFSC estimates one potential take of either a pygmy or dwarf sperm whale in the CCRA based upon capture in commercial fisheries. We believe that the likelihood of either of these later species being taken in any NWFSC hook-and-line gear is low because both species tend to prefer deeper, more offshore waters and thus would have low overlap with our surveys.

In addition to the delphinids listed above, two species of pinnipeds have a history of interacting with commercial and recreational hook-and-line gear, California and Steller sea lions. Again, because the probability of interacting with NWFSC hook-and-line gear is low given the amount of research effort compared to commercial and recreational fisheries, we are requesting one potential take of each species over the five-year authorization period in the CCRA (Table 6.4).

PSRA

In the PSRA, the NWFSC uses a limited amount of trawl gear during its fisheries research. There has been one historical take of harbor seal and several other pinnipeds species are considered analogous based on this past take in research gear and their behavior/distribution (e.g., using the same haulout areas, foraging in the same area). Take of these pinnipeds was previously discussed. In addition, the NWFSC considers harbor porpoise and Dall’s porpoise to have reasonable vulnerability to capture in research trawl gear based on past captures in analogous commercial trawl fisheries along the West Coast and the fact that both of these delphinid species are found in Puget Sound. The NWFSC therefore requests one take each of harbor porpoise and Dall's porpoise in trawl gear over the five-year authorization period in the PSRA (Table 6-4).

The NWFSC also uses a limited amount of hook-and-line gear in the PSRA but there are no records of marine mammal takes on hook-and-line gear in this area in the 2015 List of Fisheries or by NWFSC research gear. Given this lack of documented takes in these gears and the mitigation measures in place to avoid interactions, the NWFSC believes the risk of marine mammal species interacting with hook-and-line research gear in the PSRA is low. However, because harbor seals and California sea lions are abundant in Puget Sound and there are numerous reports of pinnipeds taking fish off hooks in Puget Sound recreational fisheries, the NWFSC requests the take of one harbor seal and one Calfiornia sea lion over the five-year authorization period with hook-and-line gear in the PSRA (Table 6-4). We are not requesting any take of Steller sea lion with this gear as they are rare in Puget Sound.

LCRRA

The NWFSC has had no historical takes of any marine mammals in research gear in the LCRRA. The take request for marine mammals in this area is therefore based entirely on the analogy to interactions in commercial and recreational fisheries. In the LCCRA, commercial fisheries are largely limited to salmon fisheries while recreational fisheries target salmon, sturgeon, smelt, and various gamefishes (e.g., bass). The NWFSC conducts research with trawl gear, purse seines, and tangle nets in the LCRRA and considers each of them to have a reasonable risk of potential interactions with several species that commonly occur in this area (harbor seal, Steller sea lion, Calfiornia sea lion, and harbor porpoise).

NWFSC research with trawl nets is limited to several surveys in the LCCRA. There are no commercial trawl fisheries and no record of historical take in the LCCRA by research trawls so there is no analogous records on which to base a take request with this gear type in this area. However, there is known risk of trawls capturing marine mammals in other ecosystems and the common pinniped and delphinid species in the LCCRA have all been taken in trawls in other areas. Based on the small trawl survey effort and the mitigation measures in place, the NWFSC considers the potential for take in trawl gear to be small and limited to the most abundant species in the area and therefore requests one take each of the following species over the five-year authorization period in the LCCRA: harbor seal, Steller sea lion, Calfiornia sea lion, and harbor porpoise (Table 6.4).

The tangle net is designed to capture fish for tagging/measurement and safe release and has no real analog in commercial or recreational fishing gear so there is no comparable data on marine mammal interactions with this gear in other fisheries. The NWFSC considers the risk of entangling or capturing marine mammals in tangle nets to be similar to purse seine nets primarily because these two gears are fished in similar areas (lower part of the LCCRA) and both sampling methods use similar mitigation methods (Section 11). We have therefore combined tangle nets and purse seines into one category for our take request. Based on the same types of considerations as discussed above for trawl gear (i.e., demonstrated vulnerability to purse seine gear in other areas and common presence of species in the ecosystem), the NWFSC requests the take of one each of the following species in purse seine/tangle net gear over the five-year authorization period in the LCCRA: harbor seal, Steller sea lion, Calfiornia sea lion, and harbor porpoise (Table 6.4).

Killer whales have been sighted in the lower estuary but the NWFSC is not requesting any takes of killer whales in the LCRRA due to their uncommon occurrence, the small research effort at the mouth, and the mitigation measures we implement to avoid interactions with this species (Section 11). To our knowledge, no other whales have been documented in the LCCRA so no take of whales is requested in the LCCRA. Similarly, we do not believe that any other delphinid species is at risk to NWFSC research gear in the LCCRA due to the fact other species are either very rare or absent in this ecosystem.

The NWFSC does not conduct research with hook-and-line gears in the LCRRA but conducts a great deal of research with beach seines and fyke nets. The fyke nets are of the same design and fished in the same way as those fished in the Snohomish River estuary studies in Puget Sound (see descritption provided there). However, the NWFSC is not requesting takes with these gear types primarily because they are of small size, sample habitats that marine mammals rarely occur in, and fished in such a way that marine mammals can be avoided (Section 11). For example, the NWFSC uses fyke nets in small tidal channels to capture small fish (focusing on juvenile salmon) as the tide drains the channel. Marine mammals are very unlikely to be in these small estuarine wetland channel habitats.

Table 6-4 Requested Incidental Marine Mammal Takes Based on Analogy to Species Taken Commercial and Recreational Fisheries

This table summarizes the NWFSC request for combined potential takes by Mortality and Serious Injury (M&SI) and Level A harassment for species that are considered analogous (i.e., similar in vulnerability to take in the given research area and fishing gears) as species that have been taken in commercial and recreational fisheries using gears similar to those used in NWFSC research. The first number in each cell is the annual take requested and the following number in parenthesis is the total for the five-year authorization period.

Species	Requested M&SI and Level A Take Average per Year (Total for Five-year Period)						
	CCRA			PSRA		LCRRA	
	Trawl	Purse Seine	Hook-and-line	Trawl	Hook-and-line	Trawl	Purse Seine/ Tangle Net
Harbor porpoise (several stocks)	0.2 (1)	0.2 (1)	0	0.2 (1)	0	0.2 (1)	0.2 (1)
Dall's porpoise	0.2 (1)	0.2 (1)	0	0.2 (1)	0	0	0
Pacific white-sided dolphin	0	0.2 (1)	0	0	0	0	0
Risso's dolphin	0	0.2 (1)	0.2 (1)	0	0	0	0
Bottlenose dolphin (two stocks)	0.2 (1)	0	0.2 (1)	0	0	0	0
Striped dolphin	0	0	0.2 (1)		0	0	0
Short-beaked common dolphin	0.2 (1)	0.2 (1)	0.2 (1)	0	0	0	0
Long-beaked common dolphin	0.2 (1)	0	0.2 (1)	0	0	0	0
Northern right-whale dolphin	0	0.2 (1)	0	0	0	0	0
Short-finned pilot whale	0	0	0.2 (1)	0	0	0	0
Pygmy and dwarf sperm whale	0	0	0.2 (1)	0	0	0	0
Undetermined porpoise or dolphin [1]	0.2 (1)	0	0	0	0	0	0
California sea lion	0	0	0.2 (1)	0	0.2 (1)	0.2 (1)	0.2 (1)
Steller sea lion (Eastern DPS)	0	0	0.2 (1)	0	0	0.2 (1)	0.2 (1)

Species	Requested M&SI and Level A Take Average per Year (Total for Five-year Period)						
	CCRA			PSRA		LCRRA	
	Trawl	Purse Seine	Hook-and-line	Trawl	Hook-and-line	Trawl	Purse Seine/ Tangle Net
Northern fur seal (two stocks)	0	0	0	0	0	0	0
Harbor seal	1 (5)	0	0	1 (5)	0.2 (1)	0.2 (1)	0.2 (1)
Undetermined pinniped species[1]	0.2 (1)	0	0	0	0	0	0

1. See section 6.1.7

6.1.7 Undetermined Species in the CCRA

In the past, the NWFSC lethally took two "unidentified porpoises or dolphins" in trawl gear in 2009 (Table 6-1), but since the animals were quickly returned to sea, identification of species (even to family level) was not confirmed. Current handling and data collection procedures for incidentally caught marine mammals should eliminate this type of non-identification in the future, at least of dead animals retrieved on deck. However, there are still situations when a caught animal may not be identified to species with certainty. One such case might occur if a juvenile sea lion or adult phocid seal was caught in trawl gear and escaped or fell out of the net before it was retrieved on deck. Those animals are very difficult to differentiate at sea in poor lighting, making exact identification difficult. Similarly some cetacean species are difficult to identify to species under poor field conditions. Given the possibility that sometimes marine mammals - both pinnipeds and small cetaceans - may not be exactly identified at sea due to various reasons such as poor lighting, sea conditions, species similarities or, rarely sighted species, the NWFSC requests a potential take of one "unidentified dolphin or porpoise" and one "unidentified pinniped" in trawl gear in the CCRA over the five-year authorization period.

Table 6-5 provides a summary for all NWFSC requested takes for marine mammals in all gears and research areas as described in sections 6.1.4 through 6.1.7 and Tables 6-2, 6-3, and 6-4.

Table 6-5 Requested Number of Incidental Marine Mammal Takes in All NWFSC Research Areas and Gear Types

This table summarizes the NWFSC request for combined potential takes by Mortality and Serious Injury (M&SI) and Level A harassment as an annual average and over a five-year period using trawls, hook-and-line gears (including longline, rod and reel, and troll deployments), and purse seine/tangle net gear. See Section 7 for discussion of potential impacts to these species. The first number in each cell is the annual take requested and the following number in parenthesis is the total for the five-year authorization period.

Species	Requested M&SI and Level A Take Average per Year (Total for Five-year Period)										
	CCRA			PSRA		LCRRA		Total: All Areas & Gear			
	Trawl	Purse Seine	Hook-and-Line	Trawl	Hook-and-Line	Trawl	Purse Seine/ Tangle Net	Trawl	Hook-and-Line	Purse Seine/ Tangle Net	Total Requested Take for Species
Harbor porpoise (several stocks)	0.2 (1)	0.2 (1)	0	0.2 (1)	0	0.2 (1)	0.2 (1)	0.6 (3)	0	0.4 (2)	1 (5)
Dall's porpoise	0.2 (1)	0.2 (1)	0	0.2 (1)	0	0	0	0.4 (2)	0	0.2 (1)	0.6 (3)
Pacific white-sided dolphin	6 (30)	0.2 (1)	0	0	0	0	0	6 (30)	0	0.2 (1)	6.2 (31)
Risso's dolphin	1.2 (6)	0.2 (1)	0.2 (1)	0	0	0	0	1.2 (6)	0.2 (1)	0.2 (1)	1.6 (8)
Bottlenose dolphin (two stocks)	0.2 (1)	0	0.2 (1)	0	0	0	0	0.2 (1)	0.2 (1)	0	0.4 (2)
Striped dolphin	1.2 (6)	0	0.2 (1)	0	0	0	0	1.2 (6)	0.2 (1)	0	1.4 (7)
Short-beaked common dolphin	0.2 (1)	0.2 (1)	0.2 (1)	0	0	0	0	0.2 (1)	0.2 (1)	0.2 (1)	0.6 (3)
Long-beaked common dolphin	0.2 (1)	0	0.2 (1)	0	0	0	0	0.2 (1)	0.2 (1)	0	0.4 (2)
Northern right-whale dolphin	1.2 (6)	0.2 (1)	0	0	0	0	0	1.2 (6)	0	0.2 (1)	1.4 (7)
Short-finned pilot whale	0	0	0.2 (1)	0	0	0	0	0	0.2 (1)	0	0.2 (1)

Species	Requested M&SI and Level A Take Average per Year (Total for Five-year Period)										
	CCRA			PSRA		LCRRA		Total: All Areas & Gear			
	Trawl	Purse Seine	Hook-and-Line	Trawl	Hook-and-Line	Trawl	Purse Seine/ Tangle Net	Trawl	Hook-and-Line	Purse Seine/ Tangle Net	Total Requested Take for Species
Pygmy and dwarf sperm whale	0	0	0.2 (1)	0	0	0	0	0	0.2 (1)	0	0.2 (1)
Undetermined dolphin or porpoise	0.2 (1)	0	0	0	0	0	0	0.2 (1)	0	0	0.2 (1)
California sea lion	1 (5)	0	0.2 (1)	0.2 (1)	0.2 (1)	0.2 (1)	0.2 (1)	1.4 (7)	0.4 (2)	0.2 (1)	2.0 (10)
Steller sea lion (Eastern DPS)	1 (5)	0	0.2 (1)	0.2 (1)	0	0.2 (1)	0.2 (1)	1.4 (7)	0.2 (1)	0.2 (1)	1.8 (9)
Northern fur seal (two stocks)	1 (5)	0	0	0	0	0	0	1 (5)	0	0	1 (5)
Harbor seal	1 (5)	0	0	1 (5)	0.2 (1)	0.2 (1)	0.2 (1)	2.2 (11)	0.2 (1)	0.2 (1)	2.6 (13)
Undetermined pinniped species	0.2 (1)	0	0	0	0	0	0	0.2 (1)	0	0	0.2 (1)

6.1.8 Gear Types for which NWFSC Anticipates no Level A, Serious Injury or Mortality Takes

The NWFSC is requesting incidental takes of marine mammals in various types of trawl nets, purse seine gear, tangle nets, and hook-and-line gears (longline gear, rod and reel deployments, and trolling gear). At least 16 surveys and research activities covered in this LOA application do not use any of the sampling gear covered under the NWFSC incidental take request. These surveys and research activities use a variety of other gears and equipment to sample the marine environment (see Table 1-1 for project descriptions) that are not expected to result in Level A harassment, serious injury, or mortality interactions with marine mammals, including:

- Various plankton nets
- Various echosounders and sonars
- CTD profilers
- Continuous water samplers
- Video camera sleds/beam trawls
- Fish pots/holding pens
- SCUBA divers
- VR2 passive acoustic receivers
- Beach seines
- Predator exclusion cages
- Benthic settling plates
- Fyke traps
- Epibenthic tow sleds
- Electro-fishing gear
- Remote PIT detectors
- Water quality instruments

6.1.9 Mitigation and Minimization of Takes

Because of the suite of mitigation measures NWFSC has implemented, it expects the total number of marine mammals taken in these gears to decrease in the future and be substantially less than the estimated level of take when summed across all species. Current mitigation includes using an MMED on Nordic 264 surface trawls, acoustic pingers on trawls, limits on trawl tow times, marine mammal watches, a move-on rule to minimize chances for gear to be deployed with marine mammals nearby, and modified net retrieval procedures if marine mammals are sighted while gear is in the water (see Section 11 for additional information on mitigation and Section 13 for information on monitoring and reporting interactions). The NWFSC continues to look for additional ways to minimize marine mammal takes during the course of its fisheries research, such as experimenting with the best configuration for the MMED on surface trawls, develop new sampling methods that eliminate the possibility of marine mammal mortalities (e.g. video and acoustic sampling to replace fishing gear). The results of these studies are expected to influence future sampling protocols and gear development.

6.1.10 Conclusion

The NWFSC used its historical interactions with marine mammals in fisheries research surveys as a basis for estimating potential takes of these species and of other species with which it has not interacted, but which it believes shares similar vulnerabilities to trawl gear. In addition, NWFSC estimated potential takes based on takes in analogous trawl, hook-and-line, and purse seine gear used in commercial fisheries. Because of the low level of survey effort, the surveys' small geographic footprints, historical interactions, and predicted takes (lethal, serious injury, and non-serious injury combined) relative to population size, and the fact that take will likely be minimized through the implementation of the Center's proposed mitigation measures, the NWFSC believes that its activities will have a minimal impact on marine mammals in the California Current, Puget Sound, and Lower Columbia River Research Areas. The basis for this statement is discussed in greater detail in Section 7 of this application.

Further, the NWFSC notes that, despite its best efforts to estimate realistic potential marine mammal takes, it believes actual takes will be substantially lower than its take estimates and many of the species for which it estimated take would not be taken. Nevertheless, the NWFSC considers the take estimates presented here to be precautionary and to account for the maximum amount of potential take in the future based on the best information available. There is substantial inherent uncertainty in estimating numbers and species that could be potentially taken, and the NWFSC's take estimates reflect this uncertainty. Our understanding of the potential effects of NWFSC activities on marine mammals is continually evolving. Reflecting this, the Center proposes to include an adaptive management component within the application (see Section 13 of this application). This allows the Center, in concert with NMFS Office of Protected Resources, to consider, on a case-by-case basis, new data to determine whether mitigation should be modified.

6.2 Estimated 'Level B' Harassment of Marine Mammals due to Acoustic Sources and Derivation of the Estimate

Estimating sound exposures leading to behavioral and physical effects of intermittent high frequency sounds from active acoustic devices used in fisheries research is challenging for a variety of reasons. Among these are the wide variety of operating characteristics of these devices, variability in sound propagation conditions throughout the typically large areas in which they are operated, uneven (and often poorly understood) distribution of marine species, differential (and often poorly understood) hearing capabilities in marine species, and the uncertainty in the potential for effects from different acoustic systems on different species. The NWFSC took a dual approach in assessing the impacts of high-frequency active acoustic sources used in fisheries research in the CCRA, which is the only geographical area where it operates these devices.

The first approach was a qualitative assessment of potential impacts across species and sound types. This analysis considers a number of relevant biological and practical aspects of how marine species likely receive and may be impacted by these kinds of sources. This assessment (described in greater detail in Section 7.2 below) considered the best available current scientific information on the impacts of noise exposure on marine life and the potential for the types of acoustic sources used in NWFSC surveys to have behavioral and physiological effects. The results indicate that a subset of the sound sources used are likely to be entirely inaudible to all marine species, that some of the lower frequency and higher power systems will be detectable over moderate ranges for some species (although this depends strongly on inter-specific differences in hearing capabilities). As discussed in more detail (see Section 7.2), current scientific information supports the conclusion that direct physiological harm is quite unlikely but behavioral avoidance may occur to varying degrees in different species. Consequently, any potential direct injury (as defined by NMFS relative to the U.S. Marine Mammal Protection Act as Level A harassment and currently estimated as 180 and 190 dB RMS received levels respectively for cetaceans and pinnipeds) from these fisheries acoustic sound sources was deemed highly unlikely and were not directly calculated.

Building on this assessment to attempt to quantify behavioral impacts, an analytical framework was derived and applied to estimate potential Level B harassment by acoustic sources (as defined relative to the MMPA). This analysis used characteristics of active acoustic systems, their expected patterns of use in theNWFSC operational areas, and characteristics of the marine mammal species that may interact with them to estimate Level B harassment of marine mammals. This approach is relatively straightforward and (although certain adaptations enable a more realistic spatial depiction of exposed animals in the water column) relies on average density values of marine species. While the NWFSC believes this quantitative assessment benefits from its simplicity and consistency with the current NMFS guidelines regarding estimates of Level B harassment by acoustic sources, based on a number of deliberately precautionary assumptions, the resulting take estimates should be seen as a very likely substantial overestimate of behavioral harassment from the operation of these systems. Additional details on the approach used and the assumptions made that result in a conservative estimate (i.e., higher numbers of exposures at received levels identified as Level B harassment) are described in the following sections.

6.2.1 Framework for Quantitative Estimation of Potential Acoustic Harassment Takes

The discussion in section 7.2 below considers the differential frequency bands of hearing in marine animals in deriving a qualitative assessment of the probable risk of particular acoustic impacts from general categories of active acoustic sources, and is likely a more appropriate means of assessing their overall impact from a limited set of deployments given the level of scientific uncertainty in a variety of areas. However, in order to meet the compliance requirements for assessing the potential environmental impact of NWFSC operations, in this case acoustic impacts, a quantitative estimate of individual Level B harassment was required.

Different sound exposure criteria are typically used for impulsive and continuous sources (Southall et al. 2007). Under the current NMFS guidelines for calculating Level B harassment, an animal is taken if it is exposed to continuous sounds at a received level of 120 dB RMS or impulsive sounds at a received level of 160 dB RMS. These are simple step-function thresholds that do not consider the repetition or sustained presence of a sound source nor does it account for the known differential hearing capabilities between species. Sound produced by the fisheries acoustic sources here are very short in duration (typically on the order of milliseconds), intermittent, have high rise times, and are operated from moving platforms. They are consequently considered impulsive sources, which would be subject to the 160 dB RMS criterion. A mathematical method for estimating Level B harassment according to this step-function was derived and applied in the CCRA, which is the only research area where active acoustic gear is used.

The assessment paradigm for active acoustic sources used in NWFSC fisheries research is relatively straightforward and has a number of key simplifying assumptions, most of which are deliberately precautionary given the known areas of uncertainty. These underlying assumptions (described in greater detail below) very likely lead to an overestimate of the number of animals that may be exposed at the 160 dB RMS level in any one year on average for each area. Conceptually, Level B harassment may occur when a marine mammal interacts with an acoustic signal. Estimating the number of exposures at the specified received level requires several determinations, each of which is described sequentially below:

1. A detailed characterization of the acoustic characteristics of the effective sound source or sources in operation;
2. The operational areas exposed to levels at or above those associated with Level B harassment when these sources are in operation;
3. A method for quantifying the resulting sound fields around these sources; and
4. An estimate of the average density for marine mammal species in each research area.

Quantifying the spatial and temporal dimensions of the sound exposure footprint of the active acoustic devices in operation on moving vessels and their relationship to the average density of marine mammals enables a quantitative estimate of the number of individuals for which sound levels exceed NMFS Level B Harassment threshold for each area. The number of Level B harassment events is ultimately estimated as the product of the volume of water insonified at 160 dB RMS or higher and the volumetric density of animals determined from simple assumptions about their vertical stratification in the water column. Specifically, reasonable assumptions based on what is known about diving behavior across different marine mammal species were made to segregate those that predominately remain in the upper 200 meters versus those that regularly dive deeper during foraging and transit. Methods for estimating each of these calculations are described in greater detail in the following sections, along with the simplifying assumptions made, and followed by the take estimates for the CCRA.

6.2.2 NWFSC Sound Source Characteristics

An initial characterization of the general source parameters for the primary NWFSC vessels operating active acoustic sources was conducted (Table 6-6). This process enabled a full assessment of all sound sources, including those within the category 1 sources (discussed in Section 7.2 below) that are entirely outside the range of marine mammal hearing (not shown here). This auditing of the active sources also enabled a determination of the predominant sources that, when operated, would have sound footprints exceeding those from any other simultaneous sources. These sources were effectively those used directly in acoustic propagation modeling to estimate the zones within which the 160 dB RMS received level occurred.

The full range of sound sources used in fisheries acoustic surveys were considered. Many of these sources can be operated in different modes and with different output parameters. In modeling their potential impact areas for these vessels when used and also when they are operated from non-NOAA vessels used for NWFSC survey operations, those features among those given below that would lead to the most precautionary estimate of maximum received level ranges (i.e. largest insonified area) were used (e.g., lowest operating frequency). The effective beam patterns took into account the normal modes in which these sources are typically operated. While these signals are very brief and intermittent, a very conservative assumption was taken in ignoring the temporal pattern of transmitted pulses in calculating Level B harassment events. These operating characteristics of each of the predominant sound sources were used in the calculation of effective line km (Section 6.2.3) and area of exposure (Section 6.2.6) for each source in each survey.

Sources operating at frequencies above the functional hearing range of any marine mammal (typically above 180 kHz; see section 7.2) were excluded from quantitative analysis. Among those operating within the audible band of marine mammal hearing, eight predominant sources were identified as having the largest potential impact zones during operations, based on their relatively lower output frequency, higher output power, and their operational pattern of use. In determining the effective line km for each of these predominant sources (Table 6-7) the operational patterns of use relative to one another were further applied to determine which source was the predominant one operating at any point in time for each survey. When multiple sound sources were used simultaneously, the one with the largest potential impact zone in each relevant depth strata was used in calculating takes. For example, when species (e.g., sperm whales) regularly dive deeper than 200 meters, the largest potential impact zone was calculated for both depth strata and in some cases resulted in a different source being predominant in either depth strata. This enabled a more comprehensive way of accounting for maximum exposures for animals diving in a complex sound field resulting from simultaneous sources with different spatial profiles. This overall process effectively resulted in three sound sources (EK60, ME70, and SX90) comprising the total effective line km, their relative proportions depending on the nature of each survey (see Tables 6-6 and 6-7).

Table 6-6 Output Characteristics for Predominant NWFSC Acoustic Sources

Note: Calculations of effective exposure areas are made with the lowest frequency from sources with multiple frequencies; the full range of frequencies used are shown in parentheses. Abbreviations: dB re 1 µPa at 1 m = decibels referenced at one micro Pascal at one meter; km^2 = square kilometer

Acoustic system	Operating frequencies (kHz)	Source level (dB re 1 µPa at 1 m)	Nominal beam width (degrees)	Effective exposure area: Sea surface to 200 m depth (km^2)	Effective exposure area: Sea surface to depth at which sound is attenuated to 160 dB (km^2)
Simrad EK60 narrow beam echosounder	18 kHz (38, 70, 120, 200 kHz)	224	11°	0.0142	0.1411
Simrad ME70 multibeam echosounder	70 kHz (70-120 kHz)	205	140°	0.0201	0.0201
RDI ADCP Ocean Surveyor	75 kHz	223.6	40° x 100°	0.0086	0.0187
Simrad ITI trawl monitoring system	27 kHz (-33 kHz)	<200	40° x 100°	0.0032	0.0032
Simrad FS70 trawl sonar	330 kHz	216	1.9° x 20°	0.0080	0.0080
Simrad SX90 omni-directional multibeam sonar	70 kHz (70-120 kHz)	206	0°-90° tilt angle from vertical (average)	0.06538	0.1634

Table 6-7 Annual Linear Survey Distance for each NOAA Vessel and its Predominant Sources within Two Depth Strata for the California Current Ecosystem

Only sound sources that were the dominant sources of sound during NWFSC research are shown.

Vessel	Average Line kms/ Vessel	Dominant Source	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	Volume Insonified at 0-200 m Depth (km^3)	% Time Source Dominant[1] (>200m)	Line km/ Dominant Source (>200m)	Volume Insonified at >200 m Depth (km^3)
R/V *Bell M. Shimada*	18494	EK60	80%	14795	210.1	40%	7398	938.8
		Simrad ME70 multibeam echosounder	20%	3699	74.3	0%	0	0
R/V *Reuben Lasker*	4500	Simrad SX90 omni-directional multi-beam sonar	100%	4500	294.2	50%	2250	220.5

1 The deep water percentages total less than 100% because only portions of surveys are over deep water.

6.2.3 Calculating effective line km for each survey

As described below, based on the operating parameters for each source type, an estimated volume of water insonified to the 160 dB RMS received level was determined (Table 6-7). In all cases where multiple sources are operated simultaneously, the one with the largest estimated acoustic footprint (and thus higher estimated Level B harassment) was used as the effective source. This was calculated for each depth strata (0-200 m and > 200 m), where appropriate (i.e. where depth is generally < 200 m, only the exposure area for the 0-200 m depth strata was calculated). In some cases, this resulted in different sources being predominant in each depth stratum for all line km when multiple sources were in operation; this was accounted for in estimating overall exposures for species that utilize both depth strata (deep divers). The total number of line km that would be surveyed was determined, as was the relative percentage of surveyed linear km associated with each source type. The total line km for each vessel, the effective portions associated with each of the dominant source types, and the effective total km for operation for each source type is given in Table 6-7.

6.2.4 Calculating volume of water insonified to 160 dB RMS received level

The cross-sectional area of water insonified to 160+ dB RMS received level was calculated using a simple model of sound propagation loss, which accounts for the loss of sound energy over increasing range. We used a spherical spreading model (where propagation loss = 20 x log (range) - such that there would be 60 dB of attenuation over 1000 m). This is a reasonable assumption even in relatively shallow waters since, taking into account the beam angle, the reflected energy from the seafloor will be much weaker than the direct source and the volume influenced by the reflected acoustic energy would be much smaller over the relatively short ranges involved. The spherical spreading model accounted for the frequency dependent absorption coefficient and the highly directional beam pattern of most of these sound sources. For absorption coefficients, the most commonly used formulas given by Francios and Garrison (1982) were used. The lowest frequency was used for systems that are operated over a range of frequencies. The vertical extent of this area is calculated for two depth strata (surface to 200 m, and for deep water operations > 200 m, surface to range at which the on-axis received level reaches 160 dB RMS). This was applied differentially based on the typical vertical stratification of marine mammals (see Table 6.8). A simple visualization of a 2-dimensional slice of modeled sound propagation is shown below to illustrate the predicted area insonified to the 160 dB level by an EK-60 operated at 18 kHz.

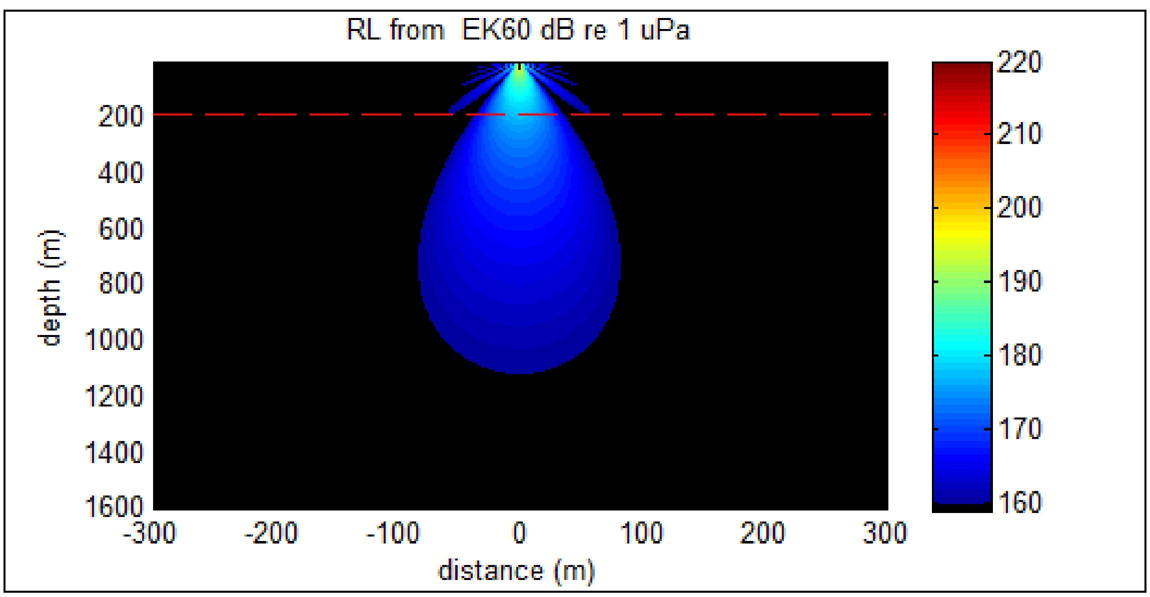

Figure 6-2 Visualization of a 2-Dimensional Slice of Modeled Sound Propagation to Illustrate the Predicted Area Insonified to the 160 dB Level by an EK-60 Operated at 18 kHz

The dashed red line marks the transition between the two depth strata (0-200 m and >200 m)

Following the determination of effective sound exposure area for transmissions considered in two dimensions, the next step was to determine the effective volume of water insonified >160 dB RMS for the entirety of each survey in each region. For each of the three predominant sound sources, the volume of water insonified is estimated as the athwartship cross-sectional area (in km^2) of sound above 160 dB RMS (as shown in the figure above) multiplied by the total distance traveled by the ship. When different sources are operating simultaneously, they may be predominant in different depth strata (e.g. if ME70 and EK60 are operating simultaneously, the ME70 could be predominant in shallow water but the EK60 could be predominant in deeper water). The resulting calculated cross sectional area took this into account. Specifically, for shallow-diving species this cross-sectional area was determined for whichever was predominant in the shallow strata whereas for deeper diving species in deeper water this area was calculated from the combined effects of the predominant source in the shallow strata and the (sometimes different) source predominating in the deeper strata) This creates an effective total volume characterizing the area insonified when each predominant source is operated and accounts for the fact that deeper diving species may encounter a complex sound field in different portion of the water column.

6.2.5 Species-specific Marine Mammal Densities

One of the primary limitations to traditional estimates of behavioral harassment takes from acoustic exposure is the assumption that animals are uniformly distributed in time and space across very large geographical areas, such as those being considered here. There is ample evidence that this is in fact not the case and marine species are highly heterogeneous in terms of their spatial distribution, largely as a result of species-typical utilization of heterogeneous ecosystem features. Some more sophisticated modeling efforts have attempted to include species typical behavioral patterns and diving parameters in movement models that more adequately assess the spatial and temporal aspects of distribution and thus exposure to sound. While simulated movement models were not used to mimic individual diving or aggregation parameters in the determination of animal density in this estimation, the vertical stratification of marine mammals based on known or reasonably assumed diving behavior was integrated into the density estimates used.

First, typical two-dimensional marine mammal density estimates (animals/km^2) were primarily obtained from Marine Mammal Stock Assessment Reports (Caretta et al. 2015 and Angliss et al. 2015), Barlow and Forney (2007), and ManTech (2007) for the CCRA (Table 3-2). These density estimates are the same values used by the SWFSC to estimate Level B harassment takes from acoustic sources for the CCRA in their separate LOA application. There are a number of caveats associated with these estimates:

- They are often calculated using visual sighting data collected during one season rather than throughout the year. The time of year when data were collected and from which densities were estimated may not always overlap with the timing of NWFSC fisheries surveys.
- The densities used for purposes of estimating acoustic harassment takes do not take into account the patchy distributions of marine mammals in an ecosystem, at least on the moderate to fine scales over which they are known to occur. Instead, animals are considered evenly distributed throughout the assessed area and seasonal movement patterns are not taken into account.

In addition and to account for at least some coarse differences in marine mammal diving behavior and the effect this has on their likely exposure to these kinds of sometimes highly directional sound sources, a volumetric density of marine mammals of each species was determined. This value is estimated as the abundance averaged over the two-dimensional geographic area of the surveys and the vertical range of typical habitat for the population. Habitat ranges were categorized in two generalized depth strata (0-200 m, and 0 to >200 m) based on gross differences between known generally surface-associated and typically deep-diving marine mammals (Reynolds and Rommel 1999, Perrin et al. 2008). Animals in the shallow diving stratum were reasonably estimated, based on empirical measurements of diving with monitoring tags and reasonable assumptions of behavior based on other indicators to spend a large majority of their lives (>75%) at depths of 200 m or shallower (Reynolds and Rommel 1999, Perrin et al. 2008). Their volumetric density and thus exposure to sound is thus limited by this depth boundary. Species in the deeper diving stratum were reasonably estimated to dive deeper than 200 m and spend 25% or more of their lives at these greater depths. Their volumetric density and thus potential exposure to sounds up to the 160 dB RMS level is extended from the surface to the depth at which this received level condition occurs. For shallow-diving species, volumetric densities were estimated by dividing the area densities by 0.2 km (200 m). For deep-diving species the volumetric densities were estimated by dividing the area densites by the depth of the area insonified to 160 dB RMS. The two-dimensional and resulting volumetric densities for each species are shown in Table 6-8.

Table 6-8 Volumetric Densities Calculated for Each Species in the CCRA used in Take Estimation

Common name	Depth Strata		Area density (number/km^2)	Volumetric density (number/km^3)
	0-200 m	>200 m		
CCRA CETACEANS				
Harbor porpoise	x		0.038	0.189
Dall's porpoise	x		0.076	0.378
Pacific white-sided dolphin	x		0.021	0.105
Risso's dolphin	x		0.010	0.052
Bottlenose dolphin	x		0.002	0.009
Striped dolphin	x		0.017	0.083
Short-beaked common dolphin	x		0.309	1.547
Long-beaked common dolphin	x		0.019	0.096
Northern right-whale dolphin	x		0.010	0.049
Killer whale	x		0.001	0.004
Short-finned pilot whale		x	0.000	0.001
Baird’s beaked whale		x	0.001	0.002
Mesoplodont beaked whale		x	0.001	0.002
Cuvier’s beaked whale		x	0.004	0.008
Pygmy sperm whale		x	0.001	0.002
Dwarf sperm whale		x	0.001	0.002
Sperm whale		x	0.002	0.003
Humpback whale	x		0.001	0.004
Blue whale	x		0.001	0.007
Fin whale	x		0.002	0.009
Sei whale	x		0.000	0.000

Common name	Depth Strata		Area density (number/km^2)	Volumetric density (number/km^3)
	0-200 m	>200 m		
Common minke whale	x		0.001	0.004
Gray whale	x		0.019	0.096
CCRA PINNIPEDS				
California sea lion	x		0.238	1.190
Steller sea lion, eastern DPS	x		0.058	0.292
Guadalupe fur seal	x		0.007	0.037
Northern fur seal	x		0.337	1.683
Harbor seal	x		0.050	0.252
Northern elephant seal		x	0.124	0.248

6.2.6 Using Areas Insonified and Volumetric Density to Calculate Acoustic Takes

Level B harassment by acoustic sources, according to current NMFS guidelines, could be calculated for each area by using (1) the combined results from output characteristics of each source and identification of the predominant sources in terms of acoustic output (6.2.2); (2) their relative annual usage patterns for each operational area (6.2.3); (3) a source-specific determination made of the area of water associated with received sounds at either the extent of a depth boundary or the 160 dB RMS received sound level (6.2.4); and (4) determination of a biologically-relevant volumetric density of marine mammal species in each area (6.2.5). These estimated takes are the product of the volume of water insonified at 160 dB RMS or higher for the predominant sound source for each portion of the total line km for which it is used and the volumetric density of animals for each species. These annual take estimates are given in Table 6.9.

Table 6-9 Estimated Annual Acoustic Takes (Level B harassment) by Sound Type for Each Marine Mammal Species in the California Current Research Area

The volume of water insonified to 160 dB by each sound source and depth strata is shown in the row below the sound source (see Table 6-3 and 6-4 for derivation). The number of Level B harassment takes for each species is derived by multiplying the volume of insonified water by the volumetric density for each species.

Species	Volumetric density (number/km^3)	Estimated Level B harassment (numbers of animals) in 0-200 m depth stratum			Estimated Level B harassment in >200 m depth stratum		Total Level B Take
		EK60	ME70	SX90	EK60	SX90	
		210.1 km^3	74.3 km^3	294.2 km^3	938.8 km^3	220.5 km^3	
CCRA CETACEANS							
Harbor porpoise[1]	0.18873	40	14	56	0	0	110
Dall's porpoise	0.37765	79	28	111	0	0	218
Pacific White-sided dolphin	0.10465	22	8	31	0	0	61
Risso's dolphin	0.05230	11	4	15	0	0	30

Species	Volumetric density (number/km^3)	Estimated Level B harassment (numbers of animals) in 0-200 m depth stratum			Estimated Level B harassment in >200 m depth stratum		Total Level B Take
		EK60	ME70	SX90	EK60	SX90	
		210.1 km^3	74.3 km^3	294.2 km^3	938.8 km^3	220.5 km^3	
Bottlenose dolphin[1]	0.00890	2	1	3	0	0	6
Striped dolphin	0.08335	18	6	25	0	0	49
Short-beaked common dolphin	1.54675	325	115	455	0	0	895
Long-beaked common dolphin	0.09620	20	7	28	0	0	55
Northern right-whale dolphin	0.04875	10	4	14	0	0	28
Killer whale[1]	0.00355	1	0	1	0	0	2
Short-finned pilot whale	0.00062	0	0	0	1	0	1
Baird's beaked whale	0.00176	0	0	1	2	0	3
Mesoplodont beaked whales	0.00206	0	0	1	2	0	3
Cuvier's beaked whale	0.00764	2	1	2	7	2	14
***Kogia* (pygmy and dwarf sperm whales)**	0.00218	0	0	1	2	0	3
Sperm whale	0.00340	1	0	1	3	1	6
Humpback whale[1]	0.00415	1	0	1	0	0	2
Blue whale	0.00680	1	1	2	0	0	4
Fin whale	0.00920	2	1	3	0	0	6
Sei whale	0.00045	0	0	0	0	0	0
Common minke whale	0.00360	1	0	1	0	0	2
Gray whale[1]	0.09565	20	7	28	0	0	55
CCRA PINNIPEDS							
California sea lion	1.19000	250	88	350	0	0	688
Steller sea lion, Eastern DPS	0.29165	61	22	86	0	0	169
Guadalupe fur seal	0.03705	8	3	11	0	0	22
Northern fur seal[1]	1.68275	354	125	495	0	0	974
Harbor seal[1]	0.25200	53	19	74	0	0	146
Northern elephant seal	0.24800	52	18	73	233	55	431

1. Estimated take is for all stocks combined. Refer to Table 3-1 for stock delineations.

6.2.7 Conclusion Regarding Total Estimates of Level B Harassment Due to Acoustic Sources

The results given in Table 6-9 are based on the approach taken here to estimate marine mammal Level B harassment takes under the MMPA and should be interpreted with considerable caution. This method is prescribed by the current definition of Level B harassment given in NMFS policy guidelines for acoustic impacts with several modifications specific to the directional nature of high-frequency fisheries acoustic sources and the vertical stratification of marine species applied. Given the simplistic step-function approach and lack of species-specific hearing parameters inherent in the NMFS prescribed approach, significant uncertainty in some areas, and a number of underlying assumptions based on how these sources may be used variably in the field, this approach should be considered to result in a highly precautionary estimate of impact (e.g., higher estimated "takes" than are in fact likely). Factors believed to result in the estimated Level B harassment by acoustic sources being conservative (i.e., higher than what may actually occur in situ) include the following:

- Based on current NMFS guidelines, the known differences in hearing sensitivities of different marine mammal species (see Section 7.2 below) are not considered in NWFSC estimates of Level B harassment by acoustic sources; all species are assumed to be equally sensitive to all acoustic systems below 180 kHz.
- Other known aspects of hearing as they relate to transient sounds (specifically auditory integration times) are also not taken into account in this estimation. Specifically, sounds associated with these fisheries acoustic sources are typically repetitive and quite brief in duration. All Sound Pressure Levels (SPLs) are calculated by assuming a continuous transmission, without taking into account the duty cycle, i.e. the ratio of pulse duration to ping interval. While some animals may potentially hear these signals well (e.g. odontocete cetaceans), for other animals, the perceived sound loudness may be considerably reduced based on their brief nature and the fact that auditory integration times in many species likely exceed the duration of individual signals.
- Density estimates underlying take calculations presume a uniform distribution of animals, while in reality for most species they are considerably patchy. The use of vertical stratification and volumetric density here is an improvement over simple geographical density estimates, although a homogenous distribution (albeit in three dimensions) is still used.
- Several other precautionary assumptions are made, including a fairly conservative interpretation of beamwidth of these directional sources (using the highest intensity beam width and propogation angle for multibeam systems) and the use of the lowest frequencies (with greatest potential propagation to higher received levels) in cases where multiple frequencies are used, e.g., the volume insonified by use of the EK60 was calculated using 18 kHz (Table 6-6).
- It should be recognized that the estimates of acoustic take take into account that more than one animal could be ensonified several times and the total estimated take can not be directly compared to the total number of animals in any particular population stock.

In conclusion, the estimated Level B harassment likely overestimates the actual magnitude of behavioral impacts of these operations for the reasons given above. This approach is deemed appropriate despite some of the uncertainties in terms of response thresholds to these types of sounds, overall density estimates, and other complicating factors.

6.3 Estimated Level B Harassment due to Physical Presence of Fisheries Research Activities

NWFSC research activities in coastal regions, rivers and estuaries may interact with marine mammals in the water or pinnipeds hauled out on land. In the PSRA, there are numerous pinniped haulouts where the physical presence and sounds of researchers passing nearby in small boats as they travel to research sites may disturb animals present. NWFSC researchers in the PSRA are very aware of this situation and take precautions to minimize the frequency and scope of potential disturbances, including choosing travel routes as far away from hauled out pinnipeds as possible and by moving sample site locations to avoid consistent haulout areas. However, there are many narrow channels among the islands of Puget Sound where the options for vessel traffic are limited. Combined with the fact that pinnipeds may haul out in new locations on a regular basis, it is essentially impossible for researchers to completely avoid disturbing pinnipeds as they travel around.

In order to estimate level B harassment takes of pinnipeds due to the physical presence of researchers, we surveyed the researchers working in the PSRA to determine the location and frequency of their research efforts in relation to haulouts. We then used Jeffries et al. (2000) to determine the numbers of harbor seals and California sea lions on these haulouts that were likely to be encountered (within about 1 nautical mile) by each of the PSRA surveys. We then tallied the frequency of those surveys to determine a total number of "near passes" to each haulout and multiplied by the number of animals potentially present.

Based on the locations of known haulouts (Jeffries et al. 2000) and prior field operations conducted by the NWFSC is these areas, the NWFSC estimates that about 1,440 harbor seals and 350 California sea lions on haulouts may be passed by NWFSC research vessels an average of eight times per year in the PSRA (Table 6-10). It is likely that many of these animals are not disturbed as research vessels pass but NWFSC fisheries researchers have not recorded numbers of animals actually affected by their presence. Until more accurate data becomes available through the proposed new reporting program outlined later in this application, it is assumed that 100 percent of these animals may react to NWFSC research activity. This pre-cautionary approach accounts for the possible (albeit unlikely) event that all animals react to each vessel pass. Therefore, the estimated annual Level B Harassment takes for the PSRA is 11,520 incidents of harassment of harbor seals and 2,800 incidents of harassment of California sea lions.

In the LCRRA, a similar method was followed. However, the only species listed for LCCRA haulout areas is harbor seals (Jeffries et al. 2000). The NWFSC estimates that 3,000 harbor seals may be present on haulouts that are passed by NWFSC research vessels an average of 25 times per year. The number of "near passes" of these haul out areas in the LCCRA was determined by talking to investigators working in these areas. The estimated annual Level B Harassment takes is therefore about 75,000 incidents of harassment of harbor seals in the LCRRA (Table 6-7). The NWFSC recognizes these estimated take levels are likely large over-estimates and that actual taking by harassment will be considerably smaller. This level of periodic, infrequent, and temporary disturbance is unlikely to affect the use of the region by any of these species.

Table 6-10 Estimated Level B Harassment Takes of Pinnipeds on Haulouts

Species	Estimated Number of Pinnipeds on Haulouts Passed by Survey Vessels	Average Number of Passes per Year	Potential Level B Harassment Take Average per Year
PUGET SOUND RESEARCH AREA			
Harbor seals	1440	8	11,520
California sea lion	350	8	2,800
LOWER COLOMBIA RIVER RESEARCH AREA			
Harbor seals	3000	25	75,000

7.0 THE ANTICIPATED IMPACT OF THE ACTIVITY UPON THE SPECIES OR STOCK.

We anticipate that the specified activities could impact the species or stocks of marine mammals by causing mortality, serious injury, and/or Level A (non-serious injury) harassment (through gear interaction) or by causing Level B (behavioral) harassment (through use of active acoustic sources and close proximity of vessels to haulouts). These could occur through the following:

- Entanglement in nets or hook-and-line gear;
- Accidental hooking; and
- Alterations in behavior caused by acoustics sources and by close vessel approaches to pinnipeds hauled out during research activities.

Other potential effects of the activity could include hearing impairment, masking, or non-auditory physiological effects, such as stress responses, resonance, and other types of organ or tissue damage related to the use of active acoustics. However, for reasons described below, we do not expect that these effects would occur. In addition, we do not expect that the anticipated impact of the activity upon the species or stocks would include effects on marine mammals from ship collision or vessel strike (see 7.4 Collision and Ship Strike for details).

The NWFSC does not expect its survey operations or its cooperative surveys with other research entities would cause the marine mammal populations in the CCRA, PSRA, or LCRRA research areas to experience reductions in reproduction, numbers, or distribution that might appreciably reduce their likelihood of surviving and recovering in the wild. Although these surveys have the potential to adversely impact the health and condition of an individual marine mammal, we anticipate no adverse effects on annual rates of recruitment or survival of the affected marine mammal species or stocks. The Center notes, however, that marine mammal distribution and abundance is not uniform in all parts of the study area, and varies substantially in different seasons. Most marine mammal surveys are conducted during the spring, summer, and fall; however, density information is not available for every season in all the study regions. But the Center believes that the direct effects on species or stocks are minor since over the course of the operations during the past five years only 10 marine mammals have been incidentally caught (nine Pacific white-sided dolphins and one Pacific harbor seal). From a population perspective, the impacts of these incidental captures are minimal.

While there are different approaches that could be taken to evaluating the significance of anticipated interactions with marine mammals during the course of fisheries research, the Potential Biological Removal (PBR) level used in classifying commercial fisheries is well established and applicable to removals of marine mammals in fisheries research activities, as well. PBR is defined by the MMPA as the maximum number of animals that may be removed from a marine mammal stock, not including natural mortalities, while allowing that stock to reach or maintain its optimum sustainable population. The PBR level is the product of the minimum population estimate of the stock, one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size, and a recovery factor of between 0.1 and 1.0.

In using PBR to evaluate the impact of NWFSC fisheries research activities on affected marine mammal stocks, two assumptions should be noted. First, as described in Section 6.0 of this application, NWFSC has requested a single number of takes in each gear for each stock in a combined category that includes Level A injury, serious injury and mortality. It is possible that some marine mammals that interact with NWFSC research gears will experience only non-serious injuries. However, for purposes of evaluating the significance of the NWFSC take request relative to PBR we assume the worst-case outcome that all animals in this combined category will be seriously injured or killed. The rationale for this binning of Level A injury, serious injury and mortality takes is also described in Section 6 of this application.

Second, NWFSC is assuming its anticipated take will equal its actual take of marine mammals in fisheries research activities. PBR was developed as a tool to evaluate actual human-caused removals from a population, not anticipated future removals. Nonetheless, the take request described in Section 6.0 is based on historical interactions, and as such NWFSC believes its request is a reasonable approximation of the number of takes that may occur in the future. Clearly, the actual number of serious injuries and mortalities that result from NWFSC research will need to be evaluated to understand the significance of these activities. As described in Section 11 of this application, NWFSC plans to implement an adaptive management approach to evaluating its actual takes and continuing to revisit its mitigation measures in light of take events to ensure they are appropriate.

7.1 Physical Interactions with Fishing Gear

The NWFSC incidentally caught 42 marine mammals during fisheries related research activities from 1999-2014 (Table 6-1). All but two of these incidental take events occurred during surveys using surface trawl gear and most (33) were taken during the Juvenile Salmon PNW Coastal Survey. Species involved were Pacific white-sided dolphins (24), Steller sea lions (8), California sea lions (4, including one released alive), harbor seals (3), including one released alive), northern fur seal (1), and unidentified porpoise/dolphin (2). The three other surveys with reported marine mammal takes are the Juvenile Rockfish Survey (2), the Skagit Bay Juvenile Salmon Survey (1), and the PNW Piscine Predator and Forage Fish Survey (6). The last survey is no longer being conducted.

Several gear types used during NWFSC fisheries research surveys are similar to those used in commercial fishing operations in the CCRA and eastern North Pacific Ocean. Included are bottom, mid-water, and surface trawls, purse seines, demersal and pelagic longlines, and other hook-and-line gear (See Appendix C). However, it is important to note that even though NWFSC uses similar types of gear as that in commercial fisheries, the size, configuration, and methods of use of this gear during NWFSC research surveys differs significantly than that used in commercial operations thereby reducing the likelihood of incidental catch of marine mammals (e.g., soak and trawl times employed in research activities are much shorter in duration than in commercial fishing operations). Figure 6-1 shows the spatial distribution of marine mammals that have been taken in NWFSC surveys from 1999 through 2014. These historical takes are dispersed fairly widely and there does not appear to be any spatial pattern of high risk areas (i.e., “hot spots” for marine mammal takes) or any temporal pattern with regard to seasons or times of day.

The NWFSC has made a concerted effort to develop and implement mitigation measures to reduce the risk of such takes. These mitigation measures are part of the proposed action (continuing fisheries research program) and are described in Section 11. Most of the mitigation measures rely on visual monitoring and detection of marine mammals near the vessel or fishing gear. There are many variables that influence the effectiveness of visual monitoring at any one time, including the lighting and sea state and the capabilities of the person(s) assigned to watch, so it is impossible to determine an overall measure of effectiveness, such as how many animals may have been avoided with visual monitoring compared to having no monitors. The value of implementing some mitigation measures is therefore based on general principles and best available information even if their effectiveness at reducing takes has not been scientifically demonstrated.

Because of the low level of historical takes, as well as the low level of predicted future takes associated with the use of trawl gear, hook-and-line gear, and purse seine/tangle net gear in research activities in the CCRA, PSRA, and LCRRA, the NWFSC believes that the surveys described below: (1) will have a minimal impact on the affected species or stocks of marine mammals (based on the likelihood that the activities will not affect annual rates of recruitment or survival); and (2) will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

7.1.1 Anticipated impact of trawl, hook-and-line, and purse seine/tangle net surveys conducted in the CCRA, PSRA, and LCRRA on marine mammal stocks

Marine mammals have been caught during NWFSC research using trawl gear, primarily the Nordic 264 surface trawl but also the Modified Cobb mid-water trawl. No marine mammals have been caught during NWFSC research using other net gears such as purse seines or tangle nets or with various hook-and-line gears, including pelagic or demersal longlines or rod and reel deployments. However, the NWFSC acknowledges the risk of capturing marine mammals in purse seines and tangle nets and hook-and-line gears, as well as various trawl gears, based on the frequent presence of marine mammals near research activities and documented marine mammal interactions with similar commercial or recreational fishing gears. Mitigation measures include a move-on rule to minimize chances for gear to be deployed with marine mammals nearby and modified net retrieval procedures if marine mammals are sighted while gear is in the water (see Section 11 for additional information on mitigation and Section 13 for information on monitoring and reporting interactions). For detailed descriptions of research efforts, see see Table 1-1. For descriptions of various research gears and instruments used by the NWFSC, see Appendix C.

The NWFSC also deploys a wide variety of gears and equipment to sample the marine environment that are not considered to pose any risk of adverse gear interactions with marine mammals and are therefore not subject to specific mitigation measures and have no associated gear take requests (see section 6.1.8). Many of the research efforts using trawl, purse seine, or hook-and-lane gears also use these gears and instruments, such as plankton nets, CTDs, and video cameras.

As described in Section 6, the NWFSC relied heavily on its historic marine mammal interactions with its trawl surveys and other gear and used other relevant information in developing its take request. This section examines the impact of those potential takes relative to the status of each stock.

The impact criteria the NWFSC used to assess the magnitude of research effects on marine mammals have been developed in the context of two important factors derived from the MMPA. The first factor is the calculation of Potential Biological Removal (PBR) for each marine mammal stock. The MMPA defined PBR at 16 U.S.C. § 1362(20) as, "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." PBR was intended to serve as an upper limit guideline for anthropogenic mortality for each stock. Calculations of PBR are stock-specific and include estimates of the minimum population size, reproductive potential of the species, and a recovery factor related to the conservation status of the stock (e.g., whether the stock is listed under the Endangered Species Act (ESA) or depleted under the MMPA). NMFS and USFWS are required to calculate PBR (if possible) for each stock of marine mammals they have jurisdiction over and to report PBR in the annual marine mammal stock assessment reports (SARs) mandated by the MMPA. The PBR metric has been used extensively to assess human impacts on marine mammals in many commercial fisheries involving mortality and serious injury (M&SI) and is a recognized and acceptable metric used by NMFS Office of Protected Resources in the evaluation of commercial fisheries incidental takes of marine mammals in US waters as well as for other sources of mortality such as ship strikes.

The second factor is the categorization of commercial fisheries with respect to their adverse interactions with marine mammals. Under Section 118 of the MMPA, NMFS must classify all US commercial fisheries into one of three categories based on the level of marine mammal M&SI that occurs incidental to each fishery, which it does in the List of Fisheries (LOF) published annually. Category III fisheries are considered to have a remote likelihood of or no known incidental M&SI of marine mammals. Category II fisheries are those that have occasional incidental M&SI of marine mammals. Category I fisheries are those that have frequent incidental M&SI of marine mammals. A two-tiered classification system is used to develop the LOF, with different thresholds of incidental M&SI compared to the PBR of a given marine mammal stock.

However, the LOF criteria is primarily used for managing commercial fisheries based on their actual levels of marine mammal M&SI and is not necessarily designed to assess impacts of projected takes on a given marine mammal stock. Because the analysis of impacts of NWFSC research on marine mammals in this document is based on projected takes rather than actual takes, we use a similar but not identical model to the LOF criteria.

In spite of some fundamental differences between most NWFSC research activities and commercial fishing practices, it is appropriate to assess the impacts of incidental takes due to research in a manner similar to what is done for commercial fisheries for two reasons:

- NWFSC research activities are similar to many commercial fisheries in the fishing gear and types of vessels used, and
- NWFSC research plays a key role in supporting commercial fisheries.

For the purposes of assessing the impact of requested marine mammal takes (combined Level A Harassment and M&SI) on the respective stocks, if the projected annual M&SI of a marine mammal stock from all NWFSC research activities is less than or equal to 10 percent of PBR for that stock, the effect would be considered minor in magnitude for the marine mammal stock, similar to the LOF's Category III fisheries that have a remote likelihood of M&SI with marine mammals with no measurable population change. Projected annual gear takes from NWFSC research activities between 10 and 50 percent of PBR for that stock would be considered moderate in magnitude for the marine mammal stock, similar to the LOF's Category II fisheries that have occasional M&SI with marine mammals where population effects may be measurable. Projected annual gear takes from NWFSC research activities greater than or equal to 50 percent of PBR would be major in magnitude for the marine mammal stock, similar to the LOF's Category I fisheries that have frequent M&SI with marine mammals which measurably affect a marine mammal stock's population trend.

Table 7-1 compares the NWFSC take request for all gears used in its fisheries research relative to each stock's PBR. The take request is based on a five-year authorization period, not an annual basis, so the total take request for all gears was divided by five to provide an annual average take for each species with which to compare to the annual PBR values. For almost all stocks for which take is requested (except bottlenose dolphins), the average annual take in all gear types and all research areas combined is well below 10 percent of PBR, even if all annual takes were from a single stock for species with multiple stocks. This level of mortality, if it occurred, would be unlikely to affect the survival or reproductive success of any species and would be considered minor. The NWFSC take request also includes an average of 0.2 "undetermined dolphin or porpoise" takes per year in trawl gear. For impact analysis purposes, we must assign these undetermined takes to each dolphin and porpoise stock in addition to those takes requested for the particular stock. Under these assumptions, the combined take request would still be well below 10 percent of PBR for almost all stocks (except bottlenose dolphins) and would be considered minor in magnitude (Table 7-1).

The exceptions to the analysis above are for the California coastal stock and CA/OR/WA offshore stock of bottlenose dolphin which have very small PBR values (Table 7-1). For these stocks, the requested take of two animals over the five-year authorization period (0.4 animals per year in all gear types), if it occurred only from animals in one stock, would represent an average of 16.7 percent and 7.3 percent of their respective PBRs. Adding the "undetermined takes" to each stock would increase the percentage of PBR represented to 25.0 percent and 10.9 percent respectively (Table 4.2-17). These levels of take, if they occurred, would be considered moderate in magnitude for these two stocks of bottlenose dolphin according to the impact criteria described above. However, the assumptions of this worst case scenario (all takes occurring in a single stock and the undetermined dolphin actually being from the same stock in a given year) are highly unlikely to occur given the lack of historical takes for either of these stocks. In addition, the small population sizes of these stocks, the limited scope of NWFSC research efforts within their ranges, and the mitigation measures in place to avoid marine mammal interactions (see Section 11) further reduce the risk of gear interactions with these stocks. The NWFSC therefore considers the potential effects of NWFSC research on these stocks to be minor.

Because of the low level of historical interactions, as well as the low level of predicted future takes (mortality, serious injury, and Level A Harassment) associated with NWFSC research activities, the NWFSC believes that their activities will not affect annual rates of recruitment or survival or the health and condition of the species or stock of the requested species. The average annual human-caused mortality for these species is estimated to be less than the PBR, and as discussed above in the species accounts, they are not classified as "strategic" stocks under the MMPA. Based on this the NWFSC believes that its activities:

1. Will have a minimal impact on the affected species or stocks of marine mammals (based on the likelihood that the activities will not affect annual rates of recruitment or survival); and
2. Will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

Table 7-1 Stocks for which NWFSC is Requesting Takes in Trawl, Hook-and-line, and Purse Seine/Tangle Net Gear in the NWFSC Research Areas and Evaluation of Impact Relative to PBR.

This table summarizes information on the combined potential takes by Mortality and Serious Injury (M&SI) and Level A harassment over a five-year period using trawl, hook-and-line, purse seine, and tangle net gear. Hook-and-line gear includes deployment by rod and reel, trolling, and longline gear. All population estimates, Potential Biological Removal (PBR) values, and total annual mortality and serious injury data are from the most recent draft stock assessment reports (Allen and Angliss 2015, Carretta et al. 2015). The average annual mortality and serious injury data include known interactions with commercial fisheries and ship strikes. Note that PBR is an annual measure of mortality. The LOA application estimates potential takes for the five-year period and these have been averaged for an annual take estimate that can be compared with PBR.

Species	Minimum Population Estimate	PBR (Animals Per Year)	Potential M&SI and Level A Take Average per Year – All Research Areas Combined (total for five-year period)			Total (All Areas & Gears Combined)	Total Annual Take Request as % of PBR	Total Annual Take Request with Undetermined Animals	Total Annual Take Request with Undetermined Animals as % of PBR
			Trawl	Hook-and-line	Purse Seine &Tangle Net				
Harbor porpoise (several stocks)	Morro Bay: 2,102 Monterey Bay: 2,480 SF-Russian River: 6,625 N.CA/S.OR: 23,749 N.OR/WA Coast: 15,123 WA Inland Waters: 7,841	Morro Bay: 21 Monterey Bay: 25 SF-Russian River: 66 N.CA/S.OR: 475 N.OR/WA Coast: 151 WA Inland Waters: 63	0.6 (3)	0	0.4 (2)	1 (5)	Morro Bay: 4.8% Monterey Bay: 4.0% SF-Russian River: 1.5% N.CA/S.OR: 0.2% N.OR/WA Coast: 0.7% WA Inland Waters: 1.6%	1.2	Morro Bay: 5.7% Monterey Bay: 4.8% SF-Russian River: 1.8% N.CA/S.OR: 0.3% N.OR/WA Coast: 0.8% WA Inland Waters: 1.9%
Dall's porpoise	32,106	257	0.4 (2)	0	0.2 (1)	0.6 (3)	0.2%	0.8	0.3%
Pacific white-sided dolphin	21,406	171	6 (30)	0	0.2 (1)	6.2 (31)	3.6%	6.4	3.7%
Risso's dolphin	4,913	39	1.2 (6)	0.2 (1)	0.2 (1)	1.6 (8)	4.1%	1.8	4.6%
Bottlenose dolphin (two stocks)	CA Coastal: 290 CA/OR/WA Offshore: 684	CA Coastal: 2.4 CA/OR/WA Offshore: 5.5	0.2 (1)	0.2 (1)	0	0.4 (2)	CA Coastal: 16.7% CA/OR/WA Offshore: 7.3%	0.6	CA Coastal: 25.0% CA/OR/WA Offshore: 10.9%
Striped dolphin	8,231	82	1.2 (6)	0.2 (1)	0	1.4 (7)	1.7%	1.6	2.0%
Short-beaked common dolphin	343,990	3,440	0.2 (1)	0.2 (1)	0.2 (1)	0.6 (3)	<0.1%	0.8	<0.1%

Species	Minimum Population Estimate	PBR (Animals Per Year)	Potential M&SI and Level A Take Average per Year – All Research Areas Combined (total for five-year period)			Total (All Areas & Gears Combined)	Total Annual Take Request as % of PBR	Total Annual Take Request with Undetermined Animals	Total Annual Take Request with Undetermined Animals as % of PBR
			Trawl	Hook-and-line	Purse Seine &Tangle Net				
Long-beaked common dolphin	76,224	610	0.2 (1)	0.2 (1)	0	0.4 (2)	0.1%	0.6	0.1%
Northern right-whale dolphin	6,019	48	1.2 (6)	0	0.2 (1)	1.4 (7)	2.9%	1.6	3.3%
Short-finned pilot whale	465	4.6	0	0.2 (1)	0	0.2 (1)	4.3%	NA	NA
Pygmy and dwarf sperm whale	Pygmy: 271 Dwarf: unknown	Pygmy: 2.7 Dwarf: undetermined	0	0.2 (1)	0	0.2 (1)	Pygmy: 7.4%	NA	NA
Undetermined dolphin or porpoise	NA	NA	0.2 (1)	0	0	0.2 (1)	NA	NA	NA
California sea lion	153,337	9,200	1.4 (7)	0.4 (2)	0.2 (1)	2.0 (10)	<0.1%	2.2	<0.1%
Steller sea lion (Eastern DPS)	34,485	1,552	1.4 (7)	0.2 (1)	0.2 (1)	1.8 (9)	0.1%	2.0	0.1%
Northern fur seal (two stocks)	California: 6,722 Eastern Pacific: 541,317	California: 403 Eastern Pacific: 11,638	1 (5)	0	0	1 (5)	California: 0.2% Eastern Pacific: <0.1%	1.2	California: 0.3% Eastern Pacific: <0.1%
Harbor seal[1]	26,667	1,600	2.2 (11)	0.2 (1)	0.2 (1)	2.6 (13)	0.2%	2.8	0.2%
Undetermined pinniped species	NA	NA	0.2 (1)	0	0	0.2 (1)	NA	NA	NA

1. Population estimate and PBR values are for the California stock of harbor seals only. There are no recent population estimates or PBR determinations for the Oregon/Washington Coast, Washington Northern Inland Waters, Southern Puget Sound, or Hood Canal stocks. M & SI data are shown for individual stocks.

7.2 Disturbance and Behavioral Changes

7.2.1 Due to Physical Presence of Researchers

Center surveys may be conducted near shore where pinnipeds are hauled out and at times result in close approaches by the survey vessel during the course of its fisheries research activities. NWFSC expects some of these animals will exhibit a behavioral response to the visual stimuli (e.g., including flushing, vocalizing and head alerts), and as a result estimates of Level B harassment have been calculated (section 6.3). These events are expected to be infrequent and cause only a very temporary disturbance (minutes). However, relevant studies of pinniped populations that experience more regular vessel disturbance indicate that population level impacts are unlikely to occur. Some key findings from these studies are summarized below.

In a popular tourism area of the Pacific Northwest where human disturbances were frequent to occur, past studies observed stable populations of seals over a 20-year period (Calambokidis et al. 1991). Despite high levels of seasonal disturbance by tourists using both motorized and non-motorized vessels, Calambokidis et al. (1991) observed an increase in site use (pup rearing) and classified this area as one of the most important pupping sites for seals in the Pacific Northwest. Another study observed an increase in seal vigilance only when vessels passed the haul out site, but then vigilance relaxed within 10 minutes of the vessels' passing (Fox 2008). If vessels were frequent to occur within a short time period (e.g., 24 hours), a reduction in the total number of seals present was also observed (Fox 2008).

Based on these studies, repeated disturbance can cause behavioral disturbance and alter normal activity patterns, and as such minimizing these types of disturbances, particularly those that are frequent and prolonged, is important. However, if disturbances resulting from research activities are brief and infrequent (which is the case during NWFSC research activities), the NWFSC does not expect the close approaches to result in prolonged or permanent separation of mothers and pups or to result in responses of the frequency or magnitude that would adversely affect annual recruitment or survival or the health and condition of pinniped species or stocks.

7.2.2 Due to Noise

Characteristics of hearing and the effects of noise on marine life have been reviewed extensively (Richardson et al. 1995; Wartzok and Ketten 1999; Nowacek et al. 2007; Southall et al. 2007; Au and Hastings 2008). Several recent studies on hearing in individual species or species groups of odontocetes and pinnipeds also exist (e.g., Kastelein et al. 2009, Kastelein et al. 2013, Ruser et al. 2014).General characteristics of hearing in marine mammals is described briefly here primarily for the purposes of categorization with regard to the potential impacts of high frequency active acoustic sources, as well as current information regarding sound exposures that may be detectable, disturbing, or injurious to marine mammals.

Hearing in Marine Mammals

Within marine taxa, there is probably the most known about the hearing capabilities of marine mammals. However many species and in fact entire taxa (e.g., large whales) have not been measured directly in controlled/laboratory settings. Current knowledge is based on direct measurements (using behavioral testing methods with trained animals and electrophysiological measurements of neural responses to sound production), as well as various ways of predicting hearing sensitivity using ranges of vocalization, morphology, observed behavior, and/or taxonomic relatedness to known species (e.g., Ketten 1997; Houser et al. 2001). While less than a third of the >120 marine mammal species have been tested directly, sufficient data exist to indicate general similarities and differences within taxa (e.g., Richardson et al. 1995; Wartzok and Ketten 1999; Au and Hastings 2008) and reasonably assign marine mammal species into functional hearing groups (as in Southall et al. 2007). NOAA modified the functional hearing groups of Southall et al. (2007) to extend the upper range of low-frequency cetaceans and to divide pinnipeds into Phocids and Otariids (NOAA Fisheries 2013b). Detailed descriptions of marine mammal auditory weighting functions and functional hearing groups are available in NOAA Fisheries (2013b). Based on these functional hearing groupings, conclusions may be made about marine mammal hearing, as described below.

No direct measurements of hearing exist in large whales, primarily because of their sheer size and the resulting difficulties in housing and testing them in normal captive settings. Conclusions about their hearing capabilities must be considered somewhat speculative, but some general conclusions and predictions are possible (Richardson et al. 1995; Ketten 1997; Wartzok and Ketten 1999; Houser et al. 2001; Erbe 2002; Clark and Ellison 2004). The thirteen species of baleen whales have been determined to comprise a low frequency cetacean functional hearing group with estimated functional hearing between 7 Hz and 30 kHz (NOAA Fisheries 2013b, Southall et al. 2007; Figure 7-2). Humpback whales produce sounds with some energy above 24 kHz (Au et al. 2006), so it is possible that functional hearing could extend slightly higher in this group. Empirical measurements of Frankel (2005) in demonstrating minor avoidance behavior in gray whales to 21-25 kHz sounds and the anatomical predictions of Parks et al. (2007) are consistent with the interpretation of a slightly higher upper frequency hearing cut-off in mysticetes, perhaps extending close to 30 kHz in some species.

Odontocetes are segregated into two functional hearing groups based on their relative specialization (or lack thereof) to detect very high frequency sounds (Table 4-1). Southall et al. (2007) distinguished these into the mid-frequency cetaceans including 32 species and subspecies of “dolphins”, 6 species of larger toothed whales, and 19 species of beaked and bottlenose whales. These species are determined, based on direct behavioral and electrophysiological methods, to have functional hearing between approximately 150 Hz and 160 kHz (see references in Southall et al. 2007).

High frequency cetaceans include eight species and subspecies of true porpoises, six species and subspecies of river dolphins plus the Franciscana (*Pontoporia blainvillei*), *Kogia*, and four species of cephalorhynchids and have functional hearing between 200 Hz and 180 kHz (Southall et al. 2007, and citations therein).

The pinnipeds (seals and sea lions) function in both air and water and have functional hearing in each media. Only underwater hearing is considered here, given that the active acoustic sources associated with NWFSC research vessels are operated in water. This group includes 16 species and subspecies of sea lions and fur seals (otariids), 23 species and subspecies of true seals (phocids), and two subspecies of walrus (odobenids). Based on the existing empirical data on hearing in laboratory individuals of nine pinniped species, Southall et al. (2007) estimated functional underwater hearing sensitivity in this group to be between 75 Hz and 75 kHz, but noted that there is considerable evidence that phocid seals have a broader range of hearing sensitivity than the otariids; the use of this bandwidth is thus a precautionary estimate in terms of how high frequency sounds might affect otariid pinnipeds. To account for this, modified functional hearing groups divide pinnipeds into Phocids and Otariids, with estimated auditory bandwidths of 75 Hz to 100 kHz and 100 Hz to 40 kHz, respectively (NOAA Fisheries 2013b).

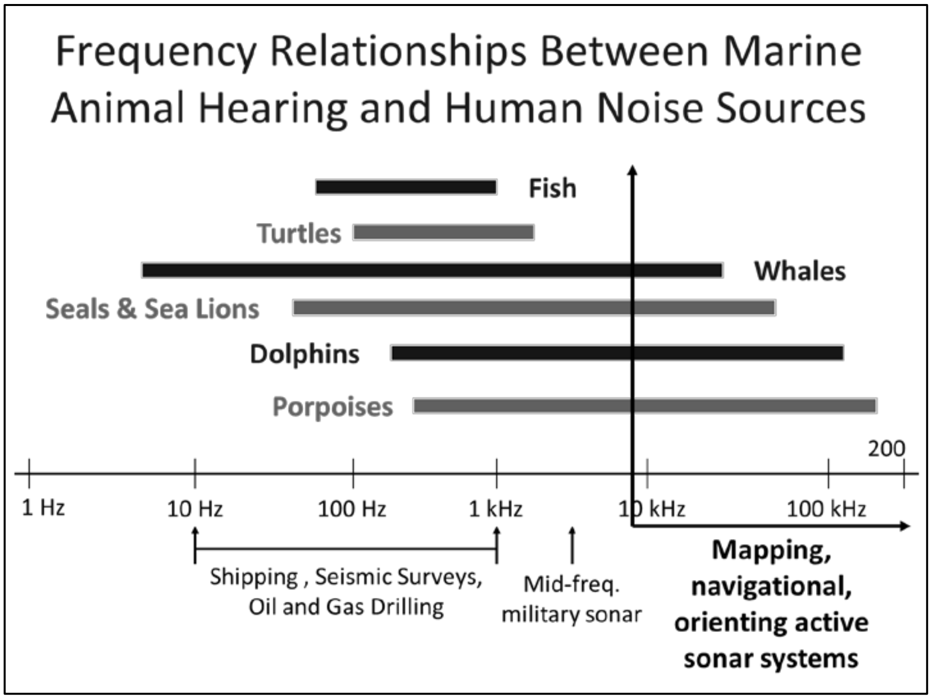

Figure 7-1 Typical Frequency Ranges of Hearing in Marine Animals Shown Relative to Various Underwater Sound Sources, Particularly High Frequency Active Acoustic Sources

Effects of anthropogenic noise on marine mammals

Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of impacts on marine life, from no or minor responses to potentially severe, depending on received levels, behavioral context and various other factors. Many of the kinds of sources that have been investigated included sounds that are either much lower frequency and/or higher total energy (considering output sound levels and signal duration) than the high frequency mapping and fish-finding sonars used by the Center. These include low- and mid-frequency military sonars, seismic airguns used in geophysical research, pile-driving sounds associated with marine construction, and low- and mid- frequency sounds associated with vessel operations (NRC 1994, 2000, 2003, 2005; Nowacek et al. 2007; Southall et al. 2007; Popper and Hastings 2009). Other than the Navy's studies on the High-Frequency Marine Mammal Monitoring (HF/M3) active sonar system since 2001, there has been relatively little attention given to the potential impacts of high-frequency sonar systems on marine life, largely because their combination of high output frequency and relatively low output power is likely to render them less likely to impact many marine species than some of the other acoustic sources. However, it should be noted that some species of marine animals do hear and produce sounds at some of the frequencies used in these sources and ambient noise is much lower at high frequencies, increasing the relative probability of their detection relative to other sounds in the environment. Because, as seen in Figure 7-2, there is very little probability of fish even hearing active high frequency acoustic sources, the primary discussion here is related to marine mammals, with particular emphasis on the odontocete cetaceans.

Sounds must presumably be audible to be detected and the known or estimated functional hearing capabilities for different species are indicated in Figure 7-1. Additionally, Southall et al. (2007) provided a recent and extensive review on the effects of noise on marine mammal hearing and behavior. The results of that review indicate that relatively high levels of sound are likely required to cause temporary hearing threshold shifts (TTS) in most pinnipeds and odontocete cetaceans species (e.g., Schlundt et al. 2000; Finneran et al. 2002, 2005, 2007b, 2010a and b; Kastak et al. 1999, 2005,2007). The exposures required are often measured with a variety of sound exposure metrics related to level (e.g., RMS, peak, or peak-

peak sound pressure level) or sound energy (e.g., sound exposure level that considers level as well as exposure duration). While clearly dependent on sound exposure frequency, level, and duration, based on the results of these studies, for the kinds of relatively brief exposures associated with transient sounds such as the active acoustic sources usd by the Center, RMS sound pressure levels in the range of approximately 180-220 dB re: 1µPa are required to induce onset TTS levels for most species (Southall et al. 2007). Recently, Lucke et al. (2009) found a TTS onset in a harbor porpoise exposed to airgun noise at much lower (>20 dB) levels than reported by Finneran et al. (2002) for belugas using a similar impulse noise source; Kastelein (unpubl. data) has similarly observed increased sensitivity in this species. Additionally, Finneran and Schlundt (2010) indicate relatively lower TTS onset levels for higher sound exposure frequencies (20 kHz) than for lower frequencies (3 kHz) in some cetaceans. However, for these animals, which are better able to hear higher frequencies and may be more sensitive to higher frequencies, exposures on the order of ~170 dB RMS or higher for brief transient signals are likely required for even temporary (recoverable) changes in hearing sensitivity that would likely not be categorized as physiologically damaging (Finneran and Schlundt 2010). The corresponding estimates for permanent threshold shift (PTS), which would be considered injurious, would still be at quite high received sound pressure levels that would rarely be experienced in practice.

Southall et al. (2007) provided a number of extrapolations to assess the potential for permanent hearing damage (permanent threshold shift or PTS) from discrete sound exposures and concluded that very high levels (exceeding 200 dB re: 1µPa received sound pressure levels) would be required; typically quite large TTS is required (~40dB) to result in PTS from a single exposure. Southall et al. (2007) also provided some frequency weighting functions for different marine mammal groups, which essentially account for the fact that impacts of noise on hearing depends in large part on the frequency overlap between noise and hearing. Based on the Southall et al. (2007) results, Lurton and DeRuiter (2011) modeled the potential impacts (PTS and behavioral reaction) of conventional echosounders on marine mammals. They estimated PTS onset at typical distances of 10s to 100m for the kinds of sources in the fisheries surveys considered here. They also emphasized that these effects would very likely only occur in the cone insonified below the ship and that animal responses to the vessel at these extremely close ranges would very likely influence their probability of being exposed to these levels. For certain species (e.g., odontocete cetaceans and especially harbor porpoises), these ranges may be somewhat greater based on more recent data (Lucke et al. 2009; Finneran and Schlundt 2010), although they are likely still on the order of hundreds of meters for most fisheries acoustic sources.

The overall conclusion here is that the available information on hearing and potential auditory effects in marine mammals would suggest that the high frequency cetacean species would be the most likely to have temporary (not permanent) hearing losses from a vessel operating high frequency sonar sources, but that even for these species, individuals would have to either be very close to and also remain very close to vessels operating these sources for multiple exposures at relatively high levels. Given the moving nature of vessels in fisheries research surveys, the likelihood that animals may avoid the vessel to some extent based on either its physical presence or active acoustic sources, and the intermittent nature of many of these sources, the potential for TTS is probably low for high frequency cetaceans and very low to zero for other species. In addition, the behavioral responses that typically occur (described below) further reduce this already low likelihood that an animal may approach close enough for any type of hearing loss to occur.

Behavioral responses of marine mammals are extremely variable depending on a host of exposure factors, including exposure level, behavioral context and other factors. The most common type of behavioral response seen across studies is behavioral avoidance of areas around sound sources. These are typically the types of responses seen in species that do clearly respond, such as harbor porpoises, around temporary/mobile higher frequency sound sources in both the field (e.g., Johnston et al. 2002) and in the laboratory settings (e.g., Kastelein et al. 2000, 2005, 2008a and b). However, what appears to be more sustained avoidance of areas where high frequency sound sources have been deployed for long durations has also been documented in some odontocete cetaceans, particularly those like porpoises and beaked whales that seem to be particularly behaviorally sensitive (e.g., Carretta et al. 2008; Southall et al. 2007). While low frequency cetaceans and pinnipeds have been observed to respond behaviorally to low- and mid-frequency sounds, there is little evidence of behavioral responses in these species to high frequency sound exposure (see e.g., Jacobs and Terhune 2002; Kastelein et al. 2006).

Active acoustic sources used by the NWFSC and their effect on marine mammals

A brief discussion of the general characteristics of high frequency acoustic sources associated with fisheries research activities is given below, followed by a qualitative assessment of how those sources may affect marine life. Marine mammals, as opposed to marine fish and sea turtles, are the focus of this assessment given their overlapping hearing capabilities (Figure 7-2) with the sounds produced by high frequency sound sources.

The high frequency transient sound sources operated by the Center are used for a wide variety of environmental and remote-object sensing in the marine environment. They include various echosounders (e.g., multi-frequency and multibeam systems), scientific sonar systems, positional sonars (e.g., net sounders for determining trawl position), and environmental sensors (e.g., current profilers). The specific acoustic sources used in NWFSC active acoustic surveys, are described in Section 6.2. As a general categorization, however, the types of active sources employed in fisheries acoustic research and monitoring may be considered in two broad categories here, based largely on their respective operating frequency (e.g., within or outside the known audible range of marine species) and other output characteristics (e.g., signal duration, directivity). As described below, these operating characteristics result in differing potential for acoustic impacts on marine mammals.

<u>Category 1 active acoustic sources</u>

Certain active fisheries acoustic sources (e.g., short range echosounders, acoustic Doppler current profilers) are distinguished by having very high output frequencies (>180 kHz) and generally short duration signals and highly directional beam patterns. Based on the frequency band of transmissions relative to the functional hearing capabilities of marine species, they are not expected to have any negative effect on marine life. They are thus not considered explicitly in the qualitative assessment below (or in the quantitative analysis conducted in Section 6.2). Additionally, passive listening sensors which are sometimes described as elements of fisheries acoustic systems that exist on many oceanographic research vessels have no potential impact on marine life because they are remotely and passively detecting sound rather than producing it.

These sources are determined to have essentially no probability of being detected by or resulting in any potential adverse impacts on marine species. This conclusion is based on the relative output frequencies (> 180 kHz) and the fact that this is above the known hearing capabilities of any marine species (as described above). Sounds that are above the functional hearing range of marine animals may be audible if sufficiently loud. However, the relative output levels of these sources and the levels that would likely be required for animals to detect them would be on the order of a few meters. The probability for injury or disturbance from these sources is essentially zero. In fact, NOAA does not regulate or require take assessments for acoustic sources with source frequencies at or above 180 kHz because they are above the functional hearing range of any known marine animal (including high frequency odontocete cetaceans, such as harbor porpoises).

<u>Category 2 active acoustic sources</u>

These acoustic sources, which are present on most NWFSC fishery research vessels, include a variety of single, dual, and multi-beam echosounders (many with a variety of modes), sources used to determine the orientation of trawl nets, and several current profilers with slightly lower output frequencies than category 1 sources. Category 2 active acoustic sources have moderate to very high output frequencies (10 to 180 kHz), generally short ping durations, and are typically focused (highly directional) to serve their intended purpose of mapping specific objects, depths, or environmental features. A number of these sources, particularly those with relatively lower sound frequencies coupled with higher output levels can be operated in different output modes (e.g., energy can be distributed among multiple output beams) that may lessen the likelihood of perception by and potential impact on marine life.

Category 2 active acoustic sources are likely to be audible to some marine mammal species. Among the marine mammals, most of these sources are unlikely to be audible to whales and most pinnipeds, whereas they may be detected by odontocete cetaceans (and particularly high frequency specialists such as harbor porpoise). There is relatively little direct information about behavioral responses of marine mammals, including the odontocete cetaceans, but the responses that have been measured in a variety of species to audible sounds (see Nowacek et al. 2007; Southall et al. 2007 for reviews) suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources.

The potential for direct physical injury from these types of active sources is low, but there is a low probability of temporary changes in hearing (masking and even temporary threshold shift) from some of the more intense sources in this category. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of best sensitivity; the TTS onset values estimated by Southall et al. (2007) were calculated with values available at that time and were from lower frequency sources. Thus, there is a potential for TTS from some of the category 2 active sources, particularly for mid- and high-frequency cetaceans. However, even given the more recent data, animals would have to be either very close (few hundreds of meters) and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (Lucke et al. 2009; Finneran and Schlundt 2010). If behavioral responses typically include the temporary avoidance that might be expected (see above), the potential for auditory effects considered physiological damage (injury) is considered extremely low so as to be negligible in relation to realistic operations of these devices.

Acoustic summary

Based on current scientific understanding and knowledge of the kinds of sources used in field operations, many of the high frequency, directional, and transient active acoustic sources used in NWFSC fisheries research operations are unlikely to be audible to and thus have no adverse impacts on most marine mammals. Sources operating at lower output frequencies, higher output levels, more continuous types of operation and with less directed acoustic energy are more likely to be audible to and affect more marine species.

Among the marine mammals, the whales and pinnipeds are the least likely to detect and be affected by these sounds. The most likely taxa to hear and react would be the odontocete cetaceans (and especially the high frequency specialized and relatively behaviorally sensitive harbor porpoises), who have specialized echolocation systems and associated high frequency hearing and excellent temporal processing of short-duration signals. The current NMFS acoustic step-function threshold of (160 dB RMS received level, irrespective of sound frequency,) is applied in the quantitative assessment in Section 6.2 because this is the current requirement. However, for many marine mammal species with reduced functional hearing at the higher frequencies produced by category 2 active sources (e.g., 40-180 kHz), based purely on their auditory abilities, the potential impacts are likely much less (or non-existent) than might be calculated in the quantitative assessment since these relevant factors are not taken into account.

For species that can detect sounds associated with high frequency active sources, based on the limited observational and experimental data on these and similar sound sources, the most likely impacts would be localized and temporary behavioral avoidance. These kinds of reactions, depending on their relative duration and severity, have been considered relatively low to moderately significant behavioral responses in the severity scaling assessment for marine mammals by Southall et al. (2007). There is a low probability of some temporary hearing impacts and an even lower probability of direct physical harm for odontocete cetaceans to the loudest kinds of these high frequency sources over very localized areas (tens of meters) around the source. There is little published evidence for marine mammal stranding events as a function of high frequency active acoustic sources. Recent analysis of potential causes of a mass stranding of 100 typically oceanic melon-headed whales (*Peponocephala electra*) in a shallow estuarine area in Madagascar in 2008 implicate a mapping survey using a high-powered 12 kHz multi-beam echosounder (MBES) as a likely trigger for this event. There was no evidence that the whales suffered hearing injuries and modeling exercises indicate they were not likely exposed to high sound levels (>160 decibels). Although the cause is equivocal and other environmental, social, or anthropogenic factors may have facilitated the strandings, the authors determined the MBES the most plausible factor initiating the stranding response, suggesting that avoidance behavior may have led the pelagic whales into shallow, unfamiliar waters (Southall et al. 2013). Although many other marine vessels around the world use sonar gear at this frequency, including some NWFSC research vessels in the CCRA, no other mass-stranding events have been documented to be associated with this type of equipment.

As a general conclusion, while some of the active acoustic sources used in NWFSC active acoustics during fisheries research surveys are likely to be detected by some marine species (particularly phocid pinnipeds and odontocete cetaceans), the potential for direct injury or hearing impairment is extremely low and the most likely responses involve temporary avoidance behavior. Consequently, and in a manner consistent with the current NMFS acoustic guidelines for defining Level B Harassment of marine mammals from impulse noise sources, a quantitative framework was developed (Section 6.2) for assessing the potential impacts of NWFSC active acoustic sources used in fisheries research.

7.3 Surveys Conducted by the NWFSC that May Take Marine Mammals by Level B Harassment Using Category 2 Acoustic Sources

Current NMFS practice regarding exposure of marine mammals to sound is that cetaceans and pinnipeds exposed to impulsive sounds of 180 and 190 dB RMS or above, respectively, are considered to have been taken by Level A (i.e., injurious) harassment. Behavioral harassment (Level B) is considered to have occurred when marine mammals are exposed to sounds at or above 160 dB RMS or impulse sounds (e.g., impact pile driving) and 120 dB RMS for continuous noise (e.g., vibratory pile driving), but below injurious thresholds. For airborne noise, pinniped disturbance from haul-outs has been documented at 100 dB for pinnipeds in general, and at 90 dB for harbor seals. NMFS uses these levels as guidelines to estimate when harassment may occur.

Level B harassment take associated with use of active acoustics equipment may occur in NWFSC fisheries research surveys. These surveys are described in Section 1.6 and Table 1-1. The NWFSC believes that the activities listed below will have a minimal impact on the affected species or stocks of marine mammals based on the likelihood that the activities will not affect annual rates of recruitment or survival.

The NWFSC only deploys active acoustic equipment that may be heard by marine mammals and produce sounds loud enough to cause potential Level B harassment in the CCRA. No such active acoustic equipment is used by the NWFSC in the LCRRA or the PSRA and no Level B takes associated with active acoustic equipment are requested for those two research areas.

7.3.1 Surveys Conducted in the CCRA that may take marine mammals by Level B harassment using category 2 acoustic sources

Level B harassment associated with use of active acoustics may occur for the following research activities that use active acoustice devices as part of their research protocols:

- Bycatch reduction research

- Camera trawl research
- Coastwide groundfish hook and line survey in untrawlable habitat
- Groundfish bottom trawl survey
- Hake acoustic survey
- Juvenile salmon PNW coastal survey
- Newport line plankton survey
- Northern juvenile rockfish survey

7.4 Collision and Ship Strike

Collisions with vessels, or ship strikes, threaten numerous marine animals and are of great concern for endangered large whales. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007). As a result ship strikes with marine mammals can lead to death by massive trauma, hemorrhaging, broken bones, or propeller wounds (Knowlton and Kraus 2001). Large whales, such as fin whales, are occasionally found draped across the bulbous bow of large ships upon arriving in port. Massive propeller wounds can be immediately fatal. If more superficial, the whales may survive the collisions (Silber et al. 2009). Jensen and Silber (2003) summarized large whale ship strikes world-wide from 1975 to 2003 and found that most collisions occurred in the open ocean involving large vessels. Commercial fishing vessels were responsible for four of 134 records (3%), and one collision (0.75%) was reported for a research boat, pilot boat, whale catcher boat, and dredge boat.

Injuries and death to marine mammals resulting from ship collisions caused by vessels during NWFSC fisheries research are not likely to occur. The probability of vessel and marine mammal interactions occurring during Center operations is negligible due to the vessel's slow operational speed, which is typically 4 kts or less. Outside of operations, each vessel's cruising speed would be approximately 10 kts, which is generally below the speed at which studies have noted reported increases of marine mammal injury or death (Laist et al., 2001).

Even though the likelihood of a ship strike is very small, we reviewed the available literature to assess the possible impact of ship strike as it applies to NWFSC survey vessels. Williams and O'Hara (2009) summarized their modeling efforts to characterize ship strikes of large cetaceans in British Columbia. Their information on ship strikes was based on ship activity provided to them by the Canadian Coast Guard. Spatially-explicit statistical modeling and Geographic Information System visualization techniques identified areas of overlap between shipping activity and waters used by humpback, fin and killer whales. Areas of highest risk were far removed from areas with high concentrations of people, suggesting that many beach-cast carcasses could go undetected. With few exceptions, high-risk areas were found in geographic bottlenecks, such as narrow straits and passageways. Although not included in the geographic area of the Williams and O'Hara study, the NWFSC survey area is such an area where large numbers of cargo ships transit the area each year, yet evidence for ship collisions are rare. Williams and O'Hara (2009) state that their risk assessments illustrate where ship strikes are most likely to occur, but cannot estimate how many strikes might occur. Propeller wounds on live killer whales were common in their study region, and fatal collisions have been reported in B.C. for all three species

In an analysis of the probability of lethal mortality of large whales at a given speed, results of a study using a logistic regression model showed that the greatest rate of change in the probability of a lethal injury to a large whale, as a function of vessel speed, occurs between vessel speeds of 8.6 and 15 knots (Vanderlaan and Taggart, 2007). Across this speed range, they found that the chances of a lethal injury decline from approximately 80% at 15 knots to approximately 20% at 8.6 knots. Notably, it is only at speeds below 11.8 knots that the chances of lethal injury drop below 50% and above 15 knots the chances asymptotically increase toward 100%. Vessels associated with the NWFSC survey project will not be traveling at speeds that could be lethal to large whales, including killer whales. Vessels associated with this project when conducting scientific research will be travelling less than 4 knots and around 10 knots during transit. Considering this slow speed and the continual bridge watches/observation for marine mammals during all ship operations, the NWFSC believes that the vessels will be able to change course if any marine mammal is sighted in the line of vessel movement and avoid a strike. Even under the remote chance that a strike occurs by a Center vessel it is unlikely to result in mortality.

Jensen and Silber (2003) summarized large whale ship strikes world-wide from 1975 to 2003 and found that most collisions occurred in the open ocean involving large vessels. Commercial fishing vessels were responsible for four of 134 records (3%), and one collision (0.75%) was reported for a research boat, pilot boat, whale catcher boat, and dredge boat.

Injuries and death to marine mammals resulting from ship collisions caused by vessels during NWFSC research are not likely to occur. The probability of vessel and marine mammal interactions occurring during Center research is unlikely due to the vessel's slow operational speed, which is typically 2 to 4 knots). Outside of operations, each vessel's cruising speed would be approximately 8 to 12 knots) which is generally below the speed at which studies have noted reported increases of marine mammal injury or death (Laist et al., 2001). Considering this slow speed and the continual observation for marine mammals during all ship, the NWFSC believes that the vessels will be able to change course if any marine mammal is sighted in the line of vessel movement and avoid a strike. Even under the remote chance that a strike occurs by a Center vessel it is unlikely to result in mortality.

There is a potential for vessels to strike cetaceans while traveling at slow speeds. For example, a NOAA contracted survey vessel traveling at low speed while conducting multibeam mapping surveys off the central California coast struck and killed a female blue whale in October 2009. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45% to 75% as vessel speed increased from 10 to 14 knots, and exceeded 90 percent at 17 knots. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne 1999; Knowlton et al. 1995). In the case of the NWFSC’s vessels, we anticipate that vessel collisions with marine mammals are unlikely, unpredictable events for which there are no preventive measures. That said, although these surveys have the potential for vessel collision, we anticipate no adverse effects on annual rates of recruitment or survival of the affected marine mammal species or stocks because of the slow speed of the vessels, the move on rule, and visual monitoring.

7.5 Conclusions Regarding Impacts of NWFSC Fisheries Research Activities on Marine Mammal Species and Stocks

As outlined in this and previous sections, there are several NWFSC fisheries research activities that have the potential to cause Level B harassment, Level A injury, and serious injury or mortality of marine mammals in the CCRA, PSRA and LCRRA study areas. However, because of the low level of historical interactions relative to the abundance of affected populations, as well as the low level of predicted future takes associated with NWFSC surveys, the NWFSC believes its activities will not affect annual rates of recruitment or survival or the health and condition of the species or stock of the requested species.

- As discussed earlier in this Section, the requested annual takes associated with entanglement or hooking in NWFSC fisheries research surveys over the five-year authorization period would not exceed any stock’s PBR, and for most affected stocks the NWFSC take request is only a small fraction of PBR.

- In the PSRA and LCRRA, the NWFSC expects that some pinnipeds hauled out or concentrated in narrow or constricted waterways will experience Level B harassment when a survey vessel passes during the course of conducting fisheries research operations. The frequency and intensity of these events are expected to be temporary and may affect only small numbers of pinnipeds. Further, cited studies on pinniped disturbance do not indicate that impacts would be of the magnitude likely to result in population-level impacts.
- In the LCRRA, the NWFSC uses a variety of techniques to deter “nuisance animals” (pinnipeds) away from fisheries research activities. These include: close approach by research vessel, in-air percussive devices such as “poppers and screamers,” and in-water detonation of seal bombs. The frequency and intensity of these events are expected to be temporary and affect only small numbers of pinnipeds. As noted in section 6.3, exposure to active percussive deterrent devices used in NWFSC fisheries research activities on “nuisance animals” is not expected to result in injury to animals and behavioral disturbance is expected to be temporary and not result in population level impacts.
- NWFSC surveys use a variety of active acoustic systems in the CCRA. These are expected to result in Level B harassment for marine mammals in close proximity to the survey vessel and its active acoustic systems. However, exposure to active acoustics used on NWFSC fisheries research surveys is not expected to result in injury to animals and behavioral disturbance is expected to be temporary and not result in population level impacts.

Based on this information the NWFSC believes that its activities will have a minimal impact on the affected species or stocks of marine mammals based on the likelihood that the activities will not affect annual rates of recruitment or survival.

8.0 THE ANTICIPATED IMPACT OF THE ACTIVITY ON THE AVAILABILITY OF THE SPECIES OR STOCKS OF MARINE MAMMALS FOR SUBSISTENCE USES.

Potential impacts resulting from the proposed action would be limited to individuals of marine mammal species located off the West Coast of the U.S., and would not affect Arctic marine mammals that are harvested for subsistence use. Therefore, there are no relevant subsistence uses of marine mammals implicated by this action as identified in MMPA Section 101(a)(5)(A)(i).

9.0 THE ANTICIPATED IMPACT OF THE ACTIVITY UPON THE HABITAT OF THE MARINE MAMMAL POPULATIONS, AND THE LIKELIHOOD OF RESTORATION OF THE AFFECTED HABITAT

The fisheries research activities conducted by the NWFSC take place in the California Current ecosystem, marine and estuarine waters of Puget Sound, and estuarine waters of the lower Columbia River. The proposed activities will not result in any permanent impact on habitats used by marine mammals or to the food resources that they utilize and thus will not affect marine mammal stocks, populations or species within the NWFSC survey areas. Modifications to the water column are expected to be short-term in nature while modifications to the sea floor from actively sampling gear (e.g., bottom trawls) may be longer-term. Expected modifications to the sea floor are insignificant relative to current and projected future levels of survey activity. The levels of removals of finfish and invertebrates relative to overall population sizes was evaluated through a separate NEPA Environmental Assessment and found to be insignificant for all common prey items of marine mammals. Potential impacts to marine mammal habitat are not anticipated to alter the function of the habitat and, therefore, will have little to no impact on marine mammal stocks or species.

9.1 Changes in Food Availability

Prey of marine mammals varies by species, season, and location and, for some, is not well documented. NWFSC fisheries research removals of commonly utilized species are few in number and small in size and typically do not include the size and age of fish taken in commercial fisheries or consumed by marine mammals. Research takes are distributed over a wide area because of the random sampling design covering large sample areas. Fish removals by research are unlikely to affect the spatial concentrations and availability of prey for these species.

There is some overlap in prey of marine mammals in the NWFSC research areas and the species sampled and removed during NWFSC research surveys. The removal by NWFSC fisheries research, regardless of season and location is, however, trivial relative to that taken through commercial and sport fisheries. The species of primary concern in regard to this overlap are Pacific hake (whiting), the small, energy-rich, schooling species such as Northern anchovy and Pacific herring, and salmonids. However, the total amount of these species taken in research surveys is very small relative to their overall commercial and recreational catches and biomass.

In addition to the small total biomass taken, some of the size classes of fish targeted in research surveys are very small (e.g., juvenile salmonids only centimeters long) and these small size classes are not generally targeted by marine mammals. Research catches are also distributed over a wide area because of random sampling designs and other sampling protocols that take small samples within large sample areas. Fish removals by research are therefore highly localized and unlikely to affect the spatial concentrations and availability of prey for any marine mammal species. This is especially true for pinnipeds, which are opportunistic predators that consume a wide assortment of fish and squid and, judging by their increasing populations and expanding ranges in the Pacific Northwest (Caretta et al. 2011), food availability does not appear to be a limiting factor (Baraff and Loughlin 2000, Scordino 2010).

For example Pacific hake is sampled during research surveys to assess abundance and age composition; approximately 1,181 mt may be harvested conducting this work; however, this results only in about 1.8 percent of the commercial catch (Table 9-1). Thus, NWFSC fish sampling during research surveys in the NWFSC fisheries research region is unlikely to effect changes in prey type, distribution, or quantity available to any marine mammals. The resulting impact of the catch level on prey resources would, therefore, be negligible.

Table 9-1 shows the average NWFSC research catch of target species in the CCRA over the past five years compared to the overfishing limit (OFL) or other metric for commercial harvests of these species.

Only species that have been taken in quantities over 1000 kg per year are shown. In most cases for which there are fishing metrics for comparison, the NWFSC research catch represents much less than 1 perent of the OFL or other metric for the target species. For all target species in the CCRA, mortality from NWFSC research surveys is considered minor on the population level.

Table 9-1 Relative Size of NWFSC Research Catch in California Current Research Area compared to Commercial Catch and 2014 Overfishing Limit.

Only target species taken in excess of 1 metric ton (1000 kg) per year and species that are overfished are shown.

Common Name	Stock Status	Average Annual Research Catch (2008-2012) From All Surveys Combined (mt)	Average Annual Commercial Catch (2008-2012) from West Coast States (mt)[1]	Average Research Catch (2008-2012) as Percent of Commercial Catch	2014 West Coast OFL[2] (mt)	Average Research Catch (2008-2012) as Percent of OFL
Pacific hake	Not overfished	1,181.0	63,974	1.8%	NA[3]	
Dover sole	Not overfished	42.9	9,044	0.5%	77,774	0.06%
Sablefish	Not overfished	25.7	6,309	0.4%	7,158	0.36%
Arrowtooth flounder	Not overfished	23.7	2,792	0.8%	6,912	0.34%
Lingcod	Not overfished	22.1	309	7.2%	4,438	0.50%
Spiny dogfish	Not overfished	21.2	280	7.6%	2,950	0.72%
Longspine thornyhead	Not overfished	20.5	Unknown		3,304	0.62%
Longnose skate	Not overfished	20.3	Unknown		2,816	0.72%
Yellowtail rockfish	Not overfished	15.9	848	1.9%	5,648	0.28%
Petrale sole	Rebuilding	14.4	1,358	1.1%	2,774	0.52%
Shortspine thornyhead	Not overfished	11.7	1,205	1.0%	2,310	0.51%
Pacific sanddab	Unknown	9.3	186	5.0%	4,801	0.19%
Pacific halibut	Not overfished	8.3	801	1.0%	NA[3]	
Widow rockfish	Not overfished	8.1	137	5.9%	4,435	0.18%
Rex sole	Unknown	7.7	444	1.7%	4,372	0.18%
Splitnose rockfish	Not overfished	7.3	35	20.6%	974	0.75%
Pacific ocean perch	Overfished	7.1	48	14.8%	838	0.85%
Pacific Herring	Monitored	7.1	834	0.9%	NA[3]	
Pacific cod	Not overfished	7.0	391	1.8%	3,200	0.22%
English sole	Not overfished	5.8	677	0.9%	5,906	0.10%
Spotted ratfish	Unknown	5.2	Unknown		1,441	0.36%

Common Name	Stock Status	Average Annual Research Catch (2008-2012) From All Surveys Combined (mt)	Average Annual Commercial Catch (2008-2012) from West Coast States (mt)[1]	Average Research Catch (2008-2012) as Percent of Commercial Catch	2014 West Coast OFL[2] (mt)	Average Research Catch (2008-2012) as Percent of OFL
Greenstriped rockfish	Not overfished	5.1	Unknown		1,501	0.34%
Chilipepper	Not overfished	4.3	240	1.8%	1,852	0.23%
Redstripe rockfish	Unknown	3.9	Unknown		270	1.44%
Northern anchovy	Monitored	3.9	4,973	0.1%	139,000	<0.01%
Sharpchin rockfish	Unknown	3.8	Unknown		224	1.69%
Pacific grenadier	Unknown	3.5	Unknown		15,190	0.02%
Canary rockfish	Overfished	3.2	13.6	23.5%	741	0.43%
Darkblotched rockfish	Rebuilding	3.1	125	2.5%	553	0.56%
Stripetail rockfish	Unknown	2.5	Unknown		64	3.91%
Whitebait smelt	Monitored	1.9	218	0.9%	NA[3]	
Giant grenadier	Unknown	1.8	124	1.5%	NA[3]	
Rougheye rockfish	Unknown	1.5	Unknown		72	2.10%
Halfbanded rockfish	Unknown	1.4	Unknown		NA[3]	
Shortbelly rockfish	Not overfished	1.4	Unknown		6,950	0.02%
Big skate	Unknown	1.3	Unknown		458	0.28%
Aurora rockfish	Not overfished	1.1	1.2	99.5%	42	2.65%
Rosethorn rockfish	Unknown	1.1	Unknown		15	7.33%
Bocaccio	Rebuilding	0.85	7	12.1%	1,165	0.07%
Cowcod	Rebuilding	<0.01	3	0.1%	12	0.04%
Yelloweye rockfish	Overfished	<0.01	3	0.1%	51	0.01%

1. Source: Commercial landing data from NMFS Office of Sustainable Fisheries website: http://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index
2. Source: Status of the Pacific Coast Groundfish Fishery, SAFE (PFMC 2014a), and Status of the Pacific Coast Pelagic Species Fishery, SAFE (PFMC 2014b)
3. For some species, an OFL has either not been established or are managed through use of concepts and strategies other than OFL. OFL is not available for these species.

9.2 Physical damage to benthic (seafloor) habitat

The potential effects of NWFSC fishery research activities on the physical environment vary depending on the survey gear and other equipment used but generally includes:

- Physical damage to benthic (seafloor) habitat
- Biological damage to infauna and epifauna
- Removal of organisms which produce structure, and
- Alteration of the turbidity and geochemistry of the water column.

Fishing gear that contacts the seafloor can physically damage seafloor habitat. Physical damage may include furrowing and smoothing of the seafloor as well as the displacement of rocks and boulders, and such damage can increase with multiple contacts in the same area (Morgan and Chuenpagdee 2003; Stevenson et al. 2004). Other survey equipment that contacts the seafloor, such as sensors and samplers, could cause localized physical damage to benthic habitats; but the effects of such equipment on benthic habitat would be limited to a very small area because this equipment is not usually dragged along the seafloor.

In general, physical damage to the seafloor recovers within 18 months through the action of water currents and natural sedimentation, with the exception of rocks and boulders which may be permanently displaced (Stevenson et al. 2004). Silt, sand, clay, and gravel are abundant at particular sites within each research area. With the exception of rock and boulder displacement, any physical impacts to benthic habitat resulting from NWFSC survey activities would be expected to recover within 18 months.

Bottom-contact fishing gear can also increase turbidity and alter the chemical composition of water near the seafloor. However, these effects would be short-term, minor in magnitude, and limited in areal extent.

The area of benthic habitat affected by NWFSC research each year would be a very small fraction of the total of the research areas. Considering the small area affected and the limited magnitude of the physical effects, the overall effects of surveys on benthic habitat in each of the NWFSC research areas would be minor.

9.3 Physical Damage to Infauna and Epifauna

Infauna are animals that live in the seafloor or within structures that are on the seafloor. Infauna usually construct tubes or burrows and are commonly found in deeper and subtidal waters. Clams, tubeworms, and burrowing crabs are infaunal animals. Epifauna live on the surface of the seafloor or on structures on the seafloor such as rocks, pilings, or vegetation. Epifauna may attach themselves to such surfaces or range freely over them, as by crawling or swimming. Mussels, crabs, starfish, and flounder are epifaunal animals. Fishing gear that contact the seafloor can disturb infauna and epifauna by crushing them, burying them or exposing them to predators (Morgan and Chuenpagdee 2003). The level of biological damage to infauna and epifauna can vary from very minimal to more severe particularly with repeated disturbance in the same areas (Stevenson et al. 2004).

The recovery time for damage to infauna and epifauna varies based on the type of fishing gear used, the type of seafloor surface (i.e., mud, sand, gravel, mixed substrate), and the level of repeated disturbances. In general, biological damage from a single disturbance is 1-18 months, and up to 3 years from repeated disturbances (Stevenson et al. 2004). Because research surveys are conducted in the same areas but not in the exact same locations they are expected to cause single rather than repeated disturbances in any one area. Therefore any physical damage caused by NWFSC fishery research activities would be expected to recover within 1-18 months. Given the small magnitude of area affected by research and the short-term nature of physical damage effects, these impacts to benthic habitat are considered negligible.

9.4 Removal of Organisms Which Produce Structure

Organisms such as cold water corals create structure on the seafloor that not only contain a high diversity of corals but also provide an important habitat for other infauna (Auster and Langton 1999; Stevenson et al. 2004). Cold water corals are generally slow growing, fragile and long lived that makes them particularly vulnerable to damage. Fishing gear that contacts coral can break or disrupt corals reducing structural complexity and reducing species diversity of the corals and other animals that utilize this habitat (Freiwald et al. 2004).

The removal of structural organisms may only be reversible over hundreds of years (Freiwald et al. 2004). Cold-water corals such as Lophelia pertusa are reported from the northwest region however their exact distribution and abundance are poorly understood (CORIS 2010).As such the extent of overlap between cold water corals and NWFSC survey vessels cannot be quantified. However this impact is expected to be limited given the small number and small areal extent of NWFSC surveys and funded fishery research using bottom trawl equipment. Catch records from NWFSC bottom trawl research efforts indicate that an average of 55 kgs of soft and hard corals (all species and types combined) were caught during NWFSC research in the CCRA from 2008 through 2012. Although fisheries research effects on corals may be long-term, the magnitude of this potential effect is likely to be minimal and is considered negligible.

9.5 Alteration of the Turbidity and Geochemistry of the Water Column

Fishing gear that contacts the seafloor can increase the turbidity of the water by the suspension of fine sediments and benthic algae. Suspension of fine sediments and turnover of sediment can also alter the geochemistry of the seafloor and the water column (Stevenson et al. 2004).

The impacts of alteration of turbidity and geochemistry in the water column are not very well understood (Stevenson et al. 2004). However, these types of effects from fisheries research activities as they relate to potential impacts on marine mammals would be periodic, temporary, and localized and are therefore considered negligible.

10.0 ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS

As stated in response to Question 9 above, the proposed activities are not anticipated to result in impacts to marine mammal habitats or to the food resources on which they depend. Therefore, we do not expect any long-term adverse impacts to marine mammals resulting from loss of or modification to marine mammal habitats as a result of the proposed activities.

11.0 THE AVAILABILITY AND FEASIBILITY (ECONOMIC AND TECHNOLOGICAL) OF EQUIPMENT, AND MANNER OF CONDUCTING SUCH ACTIVITY OR OTHER MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACT UPON THE AFFECTED SPECIES OR STOCKS, THEIR HABITAT, AND ON THEIR AVAILABILITY FOR SUBSISTENCE USES, PAYING PARTICULAR ATTENTION TO ROOKERIES, MATING GROUNDS, AND AREAS OF SIMILAR SIGNIFICANCE

The following suite of mitigation measures will be employed by the NWFSC during fisheries research. These procedures are the same whether the survey is conducted on board a NOAA vessel or charter vessel. The procedures described are based on protocols used during previous research surveys and/or best practices developed for commercial fisheries using similar gear. The NWFSC continually reviews its procedures and investigates options for incorporating new mitigation measures and equipment into its on-going survey programs. Evaluations of new mitigation measures include assessments of their effectiveness in reducing risk to marine mammals but any such measures must also pass safety considerations and allow survey results to remain consistent with previous data sets. Additional mitigation measures that are being proposed for further development and implementation by the NWFSC during the five-year life of the authorization are detailed in Section 11.2.

11.1 Mitigation Measures for Marine Mammals during Research with Trawl Gear

The following protocols apply to all NWFSC surveys and research projects using surface trawl gear (Nordic 264 Trawl), mid-water trawl gear (Modified Cobb Midwater Trawl, Aleutian Wing Midwater Trawl, and commercial trawl gear), and bottom trawl gear (commercial-sized bottom trawls, double rigged shrimp trawl, Poly Nor'easter bottom trawl, modified Aberdeen bottom trawl, and 2-meter beam trawl). However, the great majority of marine mammals taken in NWFSC research gear in the past have been caught in surface trawl gear. While these mitigation measures have been in place for all trawl surveys since 2009, surveys using surface trawl gear have implemented monitoring and avoidance of marine mammal practices for many years prior to 2009 and have a strong culture of marine mammal mitigation as part of their survey operations. Where differences between implementation of these measures exist between surface trawl surveys and all other trawl surveys, they are noted below.These measures are relevant to all protected species, including sea turtles, but in actual practice they apply primarily to marine mammals because sea turtles are rarely seen during NWFSC surveys and have never been caught in NWFSC research gear. Note that the NWFSC conducts joint cruises with the SWFSC (i.e., the joint hake-sardine integrated acoustics-trawl survey). During joint surveys, the mitigation measures related to gear deployment for sardine sampling (conducted at night) are the responsibility of the SWFSC scientific team under SWFSC marine mammal protocols, and the mitigation measures related to gear deployment for hake (generally conducted during the day) are the responsibility of the NWFSC scientific team using the marine mammal protocols described below.

11.1.1 Monitoring methods

- The vessel captain and bridge crew monitor for marine mammals during transit and, on surface trawl surveys, are joined by designated members of the scientific party assigned to watch for marine mammals as part of the pre-set protocols as the vessel approaches a station. Detection of marine mammals is by visual observation with the aid of bridge binoculars as necessary. In general, average effective observation distance is about 500 meters from the vessel. A number of factors influence the ability of observers to detect marine mammals, including, but not limited to; the species, size, and numbers of animals present, their distance from the vessel and behavior, lighting conditions, weather conditions, sea state, and the specific vessel being used.

- For any trawl operations that are conducted at night (regardless of survey type), mitigation methods using visual observations will be ineffectual and unreliable because potential detection distances of marine mammals are small and typically limited to the area immediately surrounding the vessel. Thus, in situations when night sampling occurs, we do not apply these mitigation proticols that rely on visual observation. When conditions make it useful, the captain and several of the science crew will watch for marine mammals. Sea state and cloud cover will have a significant effect on effectiveness of observations. The best viewing conditions occur with a full moon, winds of <5 mph and wave heights of only several feet. Night operations are conducted consistenly using the Modified Cobb trawl in the CCRA for juvenile rockfish and occasionally using the Nordic 264 net (for limited special studies). Deck lights are used when crew are working on deck but only illuminate the immediate area around the vessel.

- For surface trawl surveys, the period of marine mammal monitoring begins about 10 minutes before the vessel is on station and extends continuously until the net has been retrieved. When crew are assigned to monitor for marine mammals, they are dedicated to that task (i.e., they do not have any other duties while monitoring). As the vessel approaches the station, the captain and at least one assigned science crew monitor for marine mammals. Within several minutes of arriving on station and finishing their sampling duties, two additional science crew are assigned to monitor for marine mammals. From this point throughout the tow there are at least three assigned science crew and the vessel captain watching for marine mammals. However,, depending on the numbers of marine mammals that have been seen during the station approach or are expected at that particular place and season, additional science and vessel crew may be assigned to stand watch in different locations around the ship, with the goal of providing 360 degree monitoring coverage around the vessel. The number of crew available to monitor depends on the completion of other duties, the willingness of off-duty personnel to assist, and the need to avoid observer fatigue.

- For mid-water and bottom trawl surveys, the Chief Scientist must confirm with the captain or the bridge that no marine mammals have been seen within 500 meters of the ship or appear to be approaching the ship during a 10-minute period prior to the deployment of any trawl gear. The 10-minute observation period is conducted by the captain and bridge crew and typically occurs during transit prior to arrival at the sampling station, but may also include time on station if other types of gear or equipment (e.g., bongo nets) are deployed before the trawl.

- During standard trawl operations, at least some of the trackline to be towed is typically traversed prior to setting gear in order to check for hazards along the transect or, in the case of bottom trawls, to scan the bottom with echosounders to see if it is trawlable. On surface trawl surveys, CTD casts and plankton/bongo net hauls are made prior to setting the trawl. These activities can take 25-35 minutes after the vessel arrives on station, depending on water depth, and monitoring for marine mammals continues throughout these activities. Mid-water trawls and bottom trawls may not deploy other gears before deploying their trawl gear but reconnaissance of the trawl line often takes 10-15 minutes after arriving on station. In addition, once the decision is made to deploy the trawl gear, monitoring continues while the net is unspooled, which may take about 10 minutes. Before the trawl doors are deployed, the net floats on the surface behind the vessel but it is closed and actions can be taken if marine mammals are sighted near the ship (see operational procedures below). Thus, the monitoring period for marine mammals begins before the vessel arrives on station and extends continuously through gear deployment, typically for over 30 minutes on all trawl types.

- For surface trawls, monitoring for marine mammals continues after the trawl doors are deployed with a minimum of three and up to eight observers, including the bridge crew and assigned members of the science party. Care is taken to provide some rest periods for observers to avoid observer fatigue. Lookouts divide up the area around the boat to ensure at least one person is looking at each sector around the vessel. At least two pairs of binoculars are on board and available for observers to verify a potential sighting. Lookouts search for any surface sign of marine mammal (e.g. blow, splash, dorsal fin) between the times when the trawl mouth is first deployed in the water until the time the trawl mouth is recovered on deck. Lookouts immediately alert the captain and Chief Scientist as to their best estimate of the following information, relative to the ship's position, about any marine mammal or suspected marine mammal:

- Distance
- Bearing
- Type/species
- Number of individuals
- Direction of travel or behavior

- For surface trawls, monitoring all around the ship continues until the trawl retrieval begins, at which point the focus is on the stern and the trawl itself. For mid-water and bottom trawls, once the trawl doors are deployed the net sinks to the intended depth and continued monitoring of animals at the surface would not be helpful in assessing marine mammal activity at the depth of the net. There have been no NWFSC historical interactions of marine mammals when using bottom trawls and only one interaction when using the Modified Cobb mid-water trawl. The risk of interactions with these gears once the trawl doors are deployed appears to be low and monitoring efforts are reduced to the bridge crew while scientific crew attend to othe duties.
- In the case of surveys conducted aboard smaller research or chartered fishing vessels, the number of individuals and the amount of their time that may be devoted to serving as marine mammal lookouts may be limited. Under these circumstances more reliance may be placed on the captain and/or Chief Scientist to maintain a watch.

11.1.2 Operational procedures

- NWFSC fisheries research is conducted either on NOAA vessels operated by professional captains and crew from the NOAA Office of Marine and Aviation Operation (OMAO) or on chartered vessels with their own professional vessel captains and crew. The captain of the vessel has the final authority for all decisions regarding operations of the ship. The Chief Scientist has responsibility for the science mission and works collaboratively with the captain and crew to accomplish that mission. Decisions about when and where to deploy or retrieve research gear, or not deploy or retrieve gear, are made by the Chief Scientist or other designated science crew for various reasons (including the presence of marine mammals, as described below). However, the captain (or officer on watch) must consider the safety of the vessel and crew and has final authority on whether or not to carry out the decisions of the science crew.
- “Move-On” Rule. If any marine mammals are sighted within 500 meters of the vessel and are considered at risk of interacting with the vessel or research gear, or appear to be approaching the vessel and are considered at risk of interactions, the vessel has several options depending on the circumstances of the sighting. First, the set can be delayed while the vessel remains on site for some time period, usually at least 10 minutes, to see if they move off. If the marine mammals move off, the monitoring crew will conduct another 10-minute watch after the animals leave and, if no additional sightings are made, the trawl gear may be deployed. Second, the vessel may be moved away from the animals to a different section of the sampling area if the animals appear to be at risk of interaction with the gear. After the vessel is moved, monitoring protocols continue as reconnaissance of the new location is conducted and any other scientific gear is deployed (CTDs, bongos, etc.), a period of 25-35 minutes since moving to the new location. If no marine mammals

are sighted that are considered at risk of interacting with the vessel or research gear, the trawl gear may be deployed.

- Marine mammals that are sighted further than 500 meters from the vessel are monitored to determine their position and movement in relation to the vessel. If they appear to be closing on the vessel, the move-on rule protocols may be implemented even if they are initially further than 500 meters from the vessel.
- After moving on, if marine mammals are still visible from the vessel and appear to be at risk, the officer on watch, in consultation with the Chief Scientist, may decide to move again or to skip the station.
- The officer on watch will consult with the Chief Scientist or other designated scientist (identified prior to the voyage and noted on the cruise plan) and other experienced crew as necessary to determine the best strategy to avoid potential takes of marine mammals. Strategies are based on the species encountered, their numbers and behavior, their position and vector relative to the vessel, and other factors. For instance, a whale transiting through the area and heading away from the vessel may not require any move, may require a short delay before the gear is set, or may require only a short move from the initial sampling site, while a pod of dolphins gathered around the vessel may require a longer move from the initial sampling site or possibly cancellation of the station if the dolphins follow the vessel. Trawl gear is not deployed if marine mammals have been sighted within 500 meters of the ship unless those animals do not appear to be in danger of interactions with the trawl, as determined by the judgment of the Chief Scientist and officer on watch.
- During trawl operations, the most appropriate response to avoid incidental take is determined by the professional judgment of the officer on watch, in consultation with the Chief Scientist or other designated scientist and other experienced ship's crew and science crew as necessary. In general, the critical distance for deciding to retrieve the net early is an observation of a marine mammal within 500 meters of the ship or marine mammals sighted at a greater distance but clearly closing on the vessel. These judgments take into consideration the species, numbers, and behavior of the animals, type of net being used, the status of the trawl net operation (net opening, depth, and distance from the stern), the time it would take to retrieve the net, and safety considerations for changing speed or course. Because the surface trawl is more prone to capturing marine mammals, based on the historical experience of the NWFSC, decisions on what course of action to follow may be different than for a mid-water or bottom trawl. In some situations, such as whale sightings, the risk of adverse interactions may be diminished by continuing to trawl until the marine mammals have left the area before beginning haul-back operations. In other situations, swift retrieval of the net may be the best course of action. If the Chief Scientist is not on watch during a trawl, any member of the scientific party has the authority to recommend to the officer on watch to halt trawling operations if a marine mammal is observed in the vicinity and considered to be at risk. The Chief Scientist does not have to be notified before action is taken.
- All monitoring periods are documented in a logbook or on data sheets. Pertinent information includes: 1) Confirmation that the marine mammal monitoring protocol was completed prior to deployment of gear, 2) Records of any stations dropped because of the presence of marine mammals, and 3) Species or types of marine mammals observed (if possible) within 500 meters of the ship that cause an adjustment in our set protocols (e.g., extending of observation period).
- Logbooks from surface trawling operations indicate that, from 2008 through 2012, the NWFSC shortened 9.2% of tows and had to skip (not set at all) 0.9% of surface tows (out of a possible 694 tows). For comparison, 4 tows (0.6%) of the 694 conducted caught marine mammals. Shortened or skipped tows may also occur due to masses of jellyfish or gear complications but most of these incidents were because of the presence of marine mammals. The logbook data do not include the

numbers of delays or moves caused by the presence of marine mammals but the move-on rule is implemented on a regular basis, especially during May and June when migratory marine mammals are in the area.

- Care is taken when emptying the trawl, including opening the cod end as close as possible to the deck of the checker (or sorting table) in order to avoid damage to marine mammals that may be caught in the gear but are not visible upon retrieval. The gear is emptied as quickly as possible after retrieval in order to determine whether or not marine mammals are present.

11.1.3 Tow duration

- Standard tow durations are typically 30 minutes or less at the targeted depth, excluding deployment and retrieval time, to reduce the likelihood of attracting and incidentally taking marine mammals. Note that retrieval and deployment times can exceed trawling time, depending on the gear. These tow durations decrease the opportunity for curious marine mammals to find the vessel and investigate. The resulting tow distances are typically 1 to 2 nautical miles, depending on the survey and trawl speed. Additionally, although the NWFSC has never caught sea turtles in trawl gear, short tow times reduce the likelihood that incidentally captured sea turtles would drown.

11.1.4 Gear modifications

- The NWFSC is currently working to refine a marine mammal excluder device (MMED) that was incorporated on an emergency basis into the Nordic 264 surface trawl net used for the Juvenile Salmon PNW Coastal Survey. This device is a rigid grate with a set of bars across the cod end of the net and an escape hatch just forward of this set of bars (Appendix A). This device was originally developed by the Southwest FSC for use in its sardine survey (Dotson et al. 2010). The NWFSC has tested the net/excluder device design used by the Southwest FSC and found that it caused a significant loss of some salmon species that were the target of their research (report in prep.). More recent experiments have used video cameras attached to the net opening and near the excluder device to test different configurations of the excluder device to minimize loss of target species. The experiments have looked at adding weight and stiffeners to the flap covering the escape hatch to keep it closed and flipping the MMED so the escape hatch faces down rather than up. Based on preliminary results, this downward-pointing escape hatch appears to be the best design for minimizing loss of target species. Additional research will be necessary to calibrate catch levels in tows with the excluder device compared to past tows that did not contain the excluder (i.e., to align the new catchability rates with historical data sets). During these configuration and calibration experiments some nets will be fished without the MMED in order to provide controls for catchability. Once the NWFSC completes these experiments the MMED will be used in all future trawls with this net. The NWFSC will use high-resolution video cameras on tows made with and without the MMED both to evaluate effects of the MMED on catch and to determine if marine mammals enter the net undetected by observers and either escape on their own by swimming out of the net or through the MMED. All video data will be digitally recorded and reviewed at a later date.

11.1.5 Acoustic pinger devices

- For surface trawls only (using the Nordic 264 trawl), two pairs of acoustic signaling devices known as “pingers” are installed near the net opening, one on either side. Acoustic pingers, when submerged, emit an underwater pulse of sound, or “ping”. The intent of these devices is to discourage marine mammals from entering the net (see Appendix A in the accompanying EA).

- Pingers are manufactured by a number of companies but two brands typically used by the NWFSC include the Aquatec Subsea Limited, model AQUAmark, and Fumunda Marine, models F10 and F70. Pingers remain operational at depths between 10 m and 200 m. Tones range from 200 to 400 microseconds in duration, repeated every 5 or 6 seconds, with variable frequency of 10-160 kHz. The pingers generate a maximum sound pressure level of 145 decibels (dB) root mean square referenced to 1 micropascal at one meter.

11.1.6 Vessel Strike Avoidance

- When research vessels are trawling or deploying other types of sampling gear (other than acoustic equipment), vessel speeds are less than four knots, a speed at which the probability of collision with large whales and other marine mammals is negligible. When transiting between sampling stations, NWFSC research vessels cruise at 6-14 knots, but average about ten knots. This is slower than marine mammals can swim so the risk of collisions and serious injury or mortality is still very low. In addition, NWFSC research vessel captains and crew watch for marine mammals while underway during daylight hours and take necessary actions to avoid them. There are currently no Marine Mammal Observers (MMOs) aboard the vessels dedicated to watching for marine mammals to minimize the risk of collisions, although the large NOAA vessels operated by the NOAA Corps (e.g., R/V *Bell M. Shimada*) include one bridge crew dedicated to watching for obstacles at all times, including marine mammals. When research vessels are operating in areas and times when many marine mammals have been seen, additional crew may be brought up to the bridge to monitor for whales and captains may also reduce speed to improve the chances of observing whales and avoiding them. At any time during a survey or in transit, any bridge personnel that sights marine mammals that may intersect with the vessel course immediately communicates their presence to the helm for appropriate course alteration or speed reduction as possible to avoid incidental collisions, particularly with large whales.

11.2 Mitigation Measures for Marine Mammals during Research with Purse Seine Gear

- Several projects use either commercial herring seines (1500 feet x 90 feet) or research seines (500 feet x 30 feet) (see Appendix A). The crew keep watch for marine mammals before and during a set. If a bird or marine mammal observer is on board, the observer(s) inform the Chief Scientist and captain of any marine mammals detected at or near a sampling station. Observations focus on avoidance of cetaceans (e.g., killer whales, dolphins, and porpoises) and aggregations of pinnipeds.
- Small numbers of pinnipeds are often attracted to fish caught in the purse seine and frequently jump into the net, catch a fish, and jump back out of the net without getting entangled. The net will not be opened if only pinnipeds enter it. If pinnipeds are in the immediate area where the net is to be set, the set is delayed until the animals move out of the area or the station is abandoned. However, if small numbers of pinnipeds (generally less than five) are seen in the vicinity but do not appear to be in the direct way of the setting operation, the net may be set. The decision to set the net even if a few pinnipeds are visible is an attempt to balance the risk of capturing pinnipeds and the need to complete the research when small numbers of pinnipeds are present, which occurs frequently.
- If any dolphins or porpoises are observed within about 500 meters of the vessel, the net will not be set until the animals move further away. If any dolphins or porpoises are observed in the net, the net will be immediately opened to let the animals go.
- If killer whales are seen at any distance, the net will not be set and the move-on rule is applied. Note that other whales are very rare in Puget Sound but sightings would elicit the same response as killer whales.

11.3 Mitigation Measures for Marine Mammals during Research with Beach Seine Gear

- Beach seines are typically set inshore by small boat crews that visually survey the area for marine mammals prior to set. Sets are not made within 200 meters of any hauled out pinnipeds.
- Seines are deployed with one end held on shore by a crew member and the net slowly deployed by boat in an arc and then retrieved by pulling both ends onto shore. Typical seine hauls are less than 15 minutes with the resultant catch sampled and released. Marine mammals are unlikely to interact with the net as they would typically not remain on the shore or in the water in the presence of the field crew. If marine mammals are observed to be interacting with the gear, it is lifted and removed from the water.

11.4 Mitigation Measures for Marine Mammals during Research with Puget Sound Surface (Kodiak) Tow Net

- This gear type is a small (10 feet x 20 feet) net towed at slow speeds (about 2 knots) as close to shore as the net can be fished. It is only used in Puget Sound. The slow speed and small size of the net make it nearly impossible to catch a marine mammal because the mammals can easily outswim the net or swim out of the net if they encounter it. Because pinnipeds are common in Puget Sound and are often nearby on shore (within 50 meters) when the net is being fished, it is not possible to use a move-on rule for pinniped observations at any reasonable distance and still conduct the work. If only pinnipeds are observed in the area, net deployment and retrieval proceeds as specified by the research design. However, if any cetaceans are observed near a site (within about 500 meters) or appear to be approaching a site from farther out, then the site is either abandoned or the vessel holds to determine the behavior of the marine mammals (i.e., whether they are moving through or not) and then either begins fishing or moves on.

11.5 Mitigation Measures for Marine Mammals during Research with Pair Trawl Gear

- The pair trawl is operated in the Columbia River estuary at one location. The net is open (there is no bag or cod end) and it is held open in the same spot and not towed. Potentially, a marine mammal could become entangled in the net and material that holds the nets open. Mitigation for this sampling method includes having research personnel constantly monitoring this equipment and using deterrents (pyrotechnic "poppers" and "screamers" to drive sea lions or seals [pinnipeds] from the trawl area and active "seal bomb" deterrence once outside of the trawl) to dissuade pinnipedsfrom the equipment. Pinnipeds attempting to catch fish inside research gear are considered "nuisance animals" and the humane, non-lethal removal of such animals by government employees (i.e., NWFSC researchers) acting in the course of official duties is exempted under Section 109(h) of the MMPA (16 USC 1379). An occasional pinniped swimming near the trawl is tolerated but occasionally a persistent animal appears. A deckhand then approaches the pinniped in the tender skiff, which often is sufficient to dissuade the animal by itself. If the pinniped continues to approach the net and is within the trawl wings, poppers or screamers are fired from a pistol near the animal. When the animal leaves the trawl, a follow-up with a seal bomb is attempted from the chase skiff to further discourage interactions with the trawl system. An average of 26 seal bombs have been used in recent years to drive pinnipeds away from the net, all in late April and May when sea lions are most abundant in the area.

11.6 Mitigation Measures for Marine Mammals during Research with Tangle Net Gear

The tangle net is similar to a gill net in that it is designed to catch salmon by ensnaring them but there is a major difference in that the tangle net is designed to ensnare fish by their teeth rather than their gills so as not to harm them (see Appendix A). Fish that are caught are tagged with either a PIT tag or a PIT tag and an acoustic transmitter, measured, fin-clipped and released. The following mitigation measures are implemented to minimize interactions with marine mammals:

- Avoidance is the first and foremost measure taken to mitigate encounters with marine mammals. Sampling locations are rotated daily to avoid pinnipeds. If pinniped presence near the sampling nets cannot be controlled, sampling is discontinued for the day at that location.
- Pinnipeds attempting to catch fish from research gear are considered "nuisance animals" and the humane, non-lethal removal of such animals by government employees (i.e., NWFSC researchers) acting in the course of official duties is exempted under Section 109(h) of the MMPA (16 USC 1379). NMFS is in the process of developing guidelines for appropriate devices and methods to deter nuisance animals and the NWFSC will comply with the new guidance when it becomes available.
- Each sampling boat is accompanied by a skiff whose primary purpose is to patrol the net to visually deter pinnipeds through boat/human presence.
- Pyrotechnics (e.g. poppers and screamers) are used to deter pinnipeds if they approach within distances of approximately 200 yards but no closer than 70 yards. Use of these aerial devices is most effective at turning pinnipeds away and keeping them away from the sampling area if they are present in the area. In recent years, acoustic deterrents have been used 15-20 days each year (25 days maximum). The maximum number of deterrents used per day is approximately 50. Use of pyrotechnics is authorized within the sampling area by the Oregon Department of State Police Office of State Fire Marshal, through permit #A136-2011. The NWFSC will continue to comply with any laws or regulations concerning the discharge of pyrotechnics in their research areas.
- Seal bombs are used to deter predators that have approached within 20 yards of the net but are no closer than 6 feet. Seal bombs explode beneath the surface of the water and create a loud noise between the net and the pinnipeds. Their typical response is to move off several yards, but this rarely causes them to leave the area entirely. Therefore this method of deterrence is primarily used to keep pinnipeds away from the net long enough to collect the gear, remove fish from the gear, or move to another sampling location.
- The net is constructed of lightweight material which is designed to snare the fish without harming them but has an incidental benefit that it would break easily if marine mammals are caught.
- The sampling nets are typically deployed for short periods of time (25 to 45 minutes) at each location.

11.7 Mitigation Measures for Marine Mammals during Research with Longline Gear

- The NWFSC uses bottom and pelagic longline gears on a limited basis to collect specimens for aquaculture research and tagging studies. Longline efforts are conducted aboard smaller vessels and with fewer crew members than trawl surveys but the monitoring procedures for longline gear are similar to those described for trawling gear. The officer on watch, Chief Scientist (or other designated member of the scientific party), and crew standing watch visually scan, usually with binoculars, for marine mammalsduring all longline operations. The member of the crew designated to stand watch for marine mammals is dedicated to that function and visually scans the waters surrounding the vessel at least 30 minutes prior to the planned start of setting the gear into the water. Protected species monitoring would typically be performed from the wheelhouse or bridge of the vessel. However, the specific location on the vessel and the elevation above sea level from which the surveillance is conducted may be adapted to suit the size and design of the particular vessel.

- Before the gear is deployed, the "move-on" rule is implemented if any marine mammals are present near the vessel and appear to be at risk of interactions with the longline gear; longline sets are not made if marine mammals or sea turtles have been seen from the vessel within the past 30 minutes and appear to be at risk of interaction with the longline gear, as determined by the professional judgment of the Chief Scientist or officer on watch. If setting operations have been halted due to the presence of the marine mammals, setting does not resume until no marine mammals have been observed for at least 30 minutes.
- Once longline gear is in the water, monitoring for marine mammals will continue. If any are detected, the Chief Scientist or officer on watch will determine the most appropriate course of action to minimize risk of interactions based on the species, number, and behavior of the marine mammals in the area as well as the status of the ship and gear, weather and sea conditions, and crew safety factors. If appropriate, haul-back of the gear may be postponed until the officer on watch determines that it is safe to proceed.
- NWFSC longline protocols specifically prohibit chumming (i.e., releasing additional bait to attract target species to the gear). Bait is removed from hooks during retrieval and retained on the vessel until all gear is removed from the area. The crew does not discard offal or spent bait while longline gear is in the water to reduce the risk of marine mammals detecting the vessel or being attracted to the area.

11.8 Mitigation Measures for Marine Mammals during Research with Other Hook-and-line Gear

- Hook-and-line operations are used to sample groundfish in untrawlable habitats, collect species for aquaculture operations (e.g., sablefish), and to collect salmon and other species for acoustic tagging along the California, Oregon, and Washington coasts and in Puget Sound. These projects are conducted on smaller vessels and with fewer crew members than trawl surveys but the monitoring procedures for hook-and-line gear are the same as those described for longline gear. Some research projects employ contracted commercial trolling vessels deploying commercial hook-and-line gear (with barbless hooks) to conduct non-retention sampling.
- Marine mammals can be attracted to fish caught on hook-and-line gear and face potential injury from hooks as they depredate the lines. A swallowed hook or hook that remains attached to an animal (e.g., in its mouth) could cause injury. Hooks used to catch salmon present a lower risk of injury because they are barbless. Barbed hooks used to collect other species have a higher risk of injury. Protocols prohibit chumming or throwing anything overboard that might attract marine mammals during sample fishing.
- Because pinnipeds are common in Puget Sound and are often nearby on shore (within 50 meters) when the hook-and-line gear is being fished, it is not possible to use a move-on rule for pinniped observations at any reasonable distance and still conduct the work. If only pinnipeds are observed in the area, hook-and-line gear deployment proceeds as specified by the research design. However, if any cetaceans are observed near a site (within about 500 meters) and are considered to be at risk of interaction with the gear, or appear to be approaching the vessel from farther out and are considered to be at risk of interaction with the gear, then the site is either abandoned or the vessel holds to determine the behavior of the marine mammals (i.e., whether they are moving through or not) and then either begins fishing or moves on.

11.9 Plankton Nets, Oceanographic Sampling Devices, Video Cameras, SCUBA Divers, and Remotely Operated Vessel (ROV) Deployments

- The NWFSC deploys SCUBA divers and a wide variety of gear to sample the marine environment during their research cruises, such as plankton nets, oceanographic sampling devices (e.g., CTD rosettes), video cameras, and ROVs. These types of research activities are not considered to pose any risk of adverse gear interactions with marine mammals and are therefore not subject to specific mitigation measures. However, the officer on watch and crew monitor for any unusual circumstances that may arise at a sampling site and use their professional judgment and discretion to avoid any potential risks to marine mammals during deployment of all research equipment. In the case of SCUBA divers, researchers attempt to avoid pinnipeds hauled out on buoys or piers by dropping divers up-current from the target and keeping the support vessel away from the pinnipeds. However, pinnipeds may leave their haulouts to investigate the divers underwater. These types of disturbances are considered in section 6.3 of this document.

11.10 Handling Procedures for Incidentally Captured Marine Mammals

Captured live or injured marine mammals are released from research gear and returned to the water as soon as possible with no gear or as little gear remaining on the animal as possible (this is typically the responsibility of the fishing crew, not the scientific crew). Animals are released without removing them from the water if possible. Data collection is conducted in such a manner as not to delay release of the animal(s) or endanger the crew and includes as much information as possible on species, age, sex (if genital region is visible), location, description of the event, disposition at release (e.g., live, dead, hooked, entangled, amount of gear remaining on the animal, etc.), and photographs. At no time does the scientific crew attempt to acquire biological samples from an incidentally captured marine mammal, as the intent is to return the animal to its habitat as quickly and safely as possible. Immediately following an incidental capture, a set of pre-determined contacts are made to determine the course of action for the remainder of the survey.

In general, incidental captures are reported as soon as possible to the on-land Principal Investigator (PI) and recorded in the logbook. If the PI is unavailable, then one of the following individuals in the following order is contacted: Program Manager, Deputy Division Director, Division Coordinator, or Division Director. The NWFSC Environmental Compliance coordinator (currently this is Kurt Fresh with Fish Ecology Division)is contacted as soon as possible regardless of which program or division is responsible for the take as this person (or designee) is responsible for entering the information into the NMFS National Protected Species Incidental Take Data Base (PSIT) within 24 hours. The intent of this contact is to provide information for the attached incident report to be filed (time and location of incidental take, what was taken, and associated circumstances that can explain conditions leading to the take). The PI or other initial on-land contact has the responsibility to contact the Regional Administrator of the NMFS West Coast Regionand provide the report as specified in the two-page NWFSC "Report of Take" form. The West Coast Regional Administrator or representative must respond within 12 hours to the on-land PI and Chief Scientist at sea and provide clear instructions (both verbally to the Chief Scientist and by email or FAXed memo to the ship, if email/FAX is available on board) as to whether or not research operations are allowed to continue. Information on species age, sex, location and description of the event, including degree of injury, if known, should be reported to NOAA Headquarters within 24 hours. This notification occurs as a result of entering the take (within 24 hours) in the PSIT data base.

Occasionally, a decaying marine mammal carcass has been retrieved during trawling operations. These incidents are documented, photographed (if practical), returned to the sea, and reported to the PI at the completion of the cruise.

If a large whale is alive and entangled in fishing gear, the vessel immediately calls the U.S. Coast Guard (USCG) at VHF Ch. 16 and/or the appropriate Marine Mammal Health and Stranding Response Network for instructions. Entangled whales are reported to the NOAA Fisheries entanglement reporting hotline (1-877-767-9425).

11.11 Additional Mitigation Measures Proposed for Further Development and Implementation by the NWFSC during the Five-year Authorization Period.

11.11.1 Gear modifications

In addition, to the above measures, the NWFSC is proposing to implement a number of new gear modifications that would mitigate or help monitor interactions with marine mammals. These include:

- For the Pair Trawl Columbia River Juvenile Salmon Survey, experimental development of large (8 feet x 20 feet) flexible antenna housings for PIT-tag detection was begun in 2013. The NWFSC is testing the potential to replace the pair trawl net with a matrix of such large coiled antennas towed at high speed. There would be virtually no potential for marine mammal interactions with such a mobile, flexible PIT-tag detection system and no need to use various deterrence techniques for nuisance pinnipeds, such as skiff sentinels, pyrotechnics, or seal bombs. The NWFSC will implement a switch to the new flexible antenna system if it becomes practicable.
- The Groundfish Bottom Trawl Survey will add video cameras to the trawl net during calibration and experimental tows for the purpose of identifying fish and studying fish behavior as they enter the net. While this change in protocol is intended to facilitate fisheries research, it could provide incidental information about potential interactions with marine mammals, if they enter the net. No marine mammals have been caught in NWFSC bottom trawls to date.

11.11.2 Improved implementation of existing mitigation measures

To date, the specific conditions for implementing these mitigation measures in all situations have not been formalized or widely discussed among all scientific parties and vessel operators. The NWFSC therefore will be implementing a series of internal actions to improve its marine mammal training, awareness, and reporting procedures. The NWFSC expects these new procedures will facilitate and improve the implementation of the mitigation measures described in sections 11.1 through 11.9.

- The NWFSC will initiate a process for its Chief Scientists and vessel captains to communicate with each other about their experiences with marine mammal interactions during research work with the goal of improving decision-making regarding avoidance of adverse interactions. As noted previously, there are many situations where professional judgment is used to decide the best course of action for avoiding marine mammal interactions before and during the time research gear is in the water. The intent of this mitigation measure would be to draw on the collective experience of people who have been making those decisions, provide a forum for the exchange of information about what went right and what went wrong, and try to determine if there are any rules-of-thumb or key factors to consider that would help in future decisions regarding avoidance practices. The NWFSC would coordinate not only among its staff and vessel captains but also with those from other fisheries science centers with similar experience.
- The NWFSC will develop a formalized marine mammal training program for both new and experienced crew members that would be required for all NWFSC-affiliated research projects, including cooperative research partners that are funded through the NWFSC. Because of the three diverse ecosystems the NWFSC conducts its research in, training or workshops would be tailored for staff working in each research area. Training programs will be conducted on a regular basis and would include topics such as monitoring and sighting protocols, species identification, decision-making factors for avoiding take, procedures for handling and documenting marine mammals caught in research gear, and reporting requirements. The NWFSC will work with the

Northwest Fisheries Observer Program (NWFOP) to develop a customized marine mammal training program and materials appropriate for NWFSC fisheries research activities.The NWFOP currently provides marine mammal training (and other types of training) for NMFS-certified observers placed on board commercial fishing vessels. All NWFSC research crew members that may be assigned to monitor for the presence of marine mammals during future surveys will be required to attend an initial training course and refresher courses annually or as necessary. The implementation of this training program would formalize and standardize the information provided to all crew that might experience marine mammal interactions during research activities.

- For all NWFSC-affiliated research projects and vessels, written cruise instructions and protocols for avoiding adverse interactions with marine mammals will be reviewed and, if found insufficient, made fully consistent with any training materials and guidance on decision-making that arises out of the two training opportunities described above. In addition, informational placards and reporting procedures will be reviewed and updated as necessary for consistency and accuracy. Many research cruises already include pre-sail review of marine mammal protocols for affected crew but the NWFSC will emphasize the need for such pre-sail briefings and require them to be included before all research cruises, including those conducted by cooperating partners.
- The NWFSC will incorporate specific language into its contracts that specifies all training requirements, operating procedures, and reporting requirements for marine mammals that will be required for all charter vessels and cooperating partners.

12.0 WHERE THE PROPOSED ACTIVITY WOULD TAKE PLACE IN OR NEAR A TRADITIONAL ARCTIC SUBSISTENCE HUNTING AREA AND/OR MAY AFFECT THE AVAILABILITY OF A SPECIES OR STOCK OF MARINE MAMMAL FOR ARCTIC SUBSISTENCE USES, THE APPLICANT MUST SUBMIT EITHER A "PLAN OF COOPERATION" (POC) OR INFORMATION THAT IDENTIFIES WHAT MEASURES HAVE BEEN TAKEN AND/OR WILL BE TAKEN TO MINIMIZE ANY ADVERSE EFFECTS ON THE AVAILABILITY OF MARINE MAMMALS FOR SUBSISTENCE USES.

Not applicable. The proposed activity will take place off the West Coast of the United States as discussed in Section 1.2, and no activities will take place in or near a traditional Arctic subsistence hunting area. There are no relevant subsistence uses of marine mammals implicated by this action.

13.0 MONITORING AND REPORTING PLAN

13.1 Monitoring

Marine mammal watches are now a standard part of conducting fisheries research activities, particularly those that use gears (e.g., surface trawls, mid-water trawls, purse seines, tangle nets, and hook-and-line gear) that are known to interact with marine mammals or that we believe have a reasonable likelihood of doing so in the future. As described in Section 11, marine mammal watches and monitoring occur prior to deployment of gear, and they continue until gear is brought back on board. If marine mammals are sighted in the area and are considered to be at risk of interaction with the research gear then the sampling station is either moved or canceled. When marine mammal researchers are on board (distinct from marine mammal observers dedicated to monitoring for potential gear interactions) they will record the estimated species and numbers of animals present and their behavior. If marine mammal researchers are not on board or available (due to vessel size limits and bunk space) then the NWFSC will develop protocols and provide training as practical to bridge crew and other marine mammal observer crew to record such information. This information can be valuable in understanding whether some species may be attracted to vessels or gears. NOAA vessels are required to monitor interactions with marine mammals (and report interactions to the Center Director) but in reality are limited to direct interactions and reporting floaters or entangled whales. Similarly, there is a condition of grant and contract awards for monitoring of marine mammal takes.

13.2 Reporting

The NWFSC will coordinate with the local Northwest Regional Stranding Coordinator and the NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead, or floating marine mammals that are encountered during field research activities.

In the event of any incidental capture or entanglement of marine mammals in any research gear or any collisions with marine mammals with research vessels, vessel or scientific personnel will be required to contact scientific staff in the WCRO Protected Resources Division, NMFS Office of Protected Resources, the NMFS West Coast Region Stranding Network Coordinator, and the U.S. Coast Guard for guidance. This contact should be made as soon as possible and no longer than 24 hours after the incident. As part of this communication, a written report will be provided that details the events that preceded the incidental take, including the mitigation measures that were implemented and how they were implemented, whether any marine mammals were observed before the interaction occurred (species, numbers, and behavior relative to the ship or research gear), any decisions that were made regarding avoidance of the marine mammals (e.g, change of course or speed, early removal of research gear from the water, or other efforts), and a post-hoc analysis of the decision-making process before the take (e.g., who made the decision, other members of the crew or scientific party that were involved in the decision, and whether an alternative course of action may have avoided the take).

Chief Scientists provide reports to NWFSC leadership by event, survey leg and cruise. However, the Chief Scientist is not generally on the bridge during fishing operations and will need to rely on forms completed by either scientists or crew. As a result, when marine mammal takes occur or when animals are present and no takes occur a report provided by the Chief Scientist will summarize the behavior and species of animals present, weather and viewing conditions, and other important circumstances of these events that will allow the NWFSC to better evaluate the conditions under which takes are most likely occur. We believe in the long term this will allow us to avoid some of these situations in the future.

NMFS has established a formal incidental take reporting system, the Protected Species Incidental Take (PSIT) database, requiring that incidental takes of MMPA and ESA-listed species be reported within 24 hours of the occurrence. The PSIT generates automated messages to agency leadership and other relevant staff and alerts them to the event and that updated information describing the circumstances of the event have been inputted into the database. The PSIT represents not only a valuable real-time reporting and information dissemination tool, but also an archive of information that could be mined at later points in time to study why takes occur, by species, gear, etc. Ultimately, the NWFSC would hope that a single reporting tool capable of disseminating and archiving all relevant details of marine mammal interactions during fisheries research activities could be developed and implemented. Until that time, NWFSC will input data both into the PSIT database and submit detailed event reports, which will also be uploaded to PSIT.

A final and equally important component of reporting being implemented by NWFSC will facilitate serious injury (SI) determinations for marine mammals that are released alive. As discussed in Section 11, NWFSC is requiring that scientists complete data forms (adapted from those used by commercial fisheries observer programs) and address supplemental questions, both of which have been developed to aid in SI determinations. NWFSC understands the critical need to provide scientists who make serious injury determinations with as much relevant information as possible about marine mammal interactions to inform their decisions.

14.0 COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL TAKE

NOAA Fisheries and the NWFSC provide a significant amount of funding and support to marine research. Specifically, NOAA Fisheries provides significant funding annually to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. The NWFSC actively participates on Take Reduction Teams and in Take Reduction Planning and it conducts a variety of studies, convenes workshops and engages in other activities aimed at developing effective bycatch reduction technologies, gears and practices (see Bycatch Reduction Research in Table 1-1). The NWFSC will continue to foster this research to further reduce takes of marine mammals in both its operations and in commercial fisheries to the lowest practicable levels.

Following the first year of implementation of the MMPA incidental take authorization, the NWFSC will convene a workshop with West Coast Region Protected Species Division, NWFSC fishery scientists, NOAA research vessel personnel, and other NMFS staff as appropriate to review data collection, marine mammal interactions, and refine data collection and mitigation protocols, as required.

The NWFSC has a keen awareness that an increase in fisheries research effort is expected to result in more marine mammal takes over time. For this reason and because of resource limitations, the NWFSC maximizes efficient use of the charter and NOAA ship time it can attain. We also engage in operational plans with the Southwest and Alaska Fisheries Science Centers in order to clearly delineate our respective research responsibilities and to ensure we avoid research gaps and duplication of effort between Centers. In short, the NWFSC is on the water conducting fisheries research activities no more often than is necessary to fulfill its responsibilities to provide scientific advice to the West Coast Regional Office, the Pacific Fisheries Management Council, and other relevant domestic and international management bodies.

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Request for Rulemaking and Letters of Authorization Under Section 101(a)(5)(A) of the Marine Mammal Protection Act

for the Take of Marine Mammals Incidental to Fisheries Research Activities conducted by the Northwest Fisheries Science Center

Appendix A

NWFSC Research Gear and Vessel Descriptions

Prepared for the National Marine Fisheries Service by:

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1. Trawl nets

A trawl net is a funnel-shaped net towed behind a boat to capture fish. The codend, or ‘bag,’ is the fine-meshed portion of the net most distant from the towing vessel where fish and other organisms larger than the mesh size are retained. In contrast to commercial fishery operations, which generally use larger mesh to capture marketable fish, research trawls often use smaller mesh to enable estimates of the size and age distributions of fish in a particular area. The body of a trawl net is generally constructed of relatively coarse mesh that functions to gather schooling fish so they can be collected in the codend. The opening of the net, called the ‘mouth, is extended horizontally by large panels of wide mesh called ‘wings’ (Figures A-1 and A-2). For many trawl nets, the mouth of the net is held open by hydrodynamic force exerted on the trawl doors attached to the wings of the net. As the net is towed through the water, the force of the water spreads the trawl doors horizontally apart. Typically, the mouth of a trawl net is held open vertically using floatation on the upper edge, or “headrope”, and weights on the lower edge, or “footrope”. For other types of trawls, the horizontal spread of the net is maintained by a beam (beam trawl; Figure A-3) or the distance between two towing vessels (pair trawl; Figure A-4).

The trawl net is usually deployed over the stern of the vessel, and attached with two cables, or ‘warps,’ to winches on the deck of the vessel. The cables are played out until the net reaches the fishing depth. The duration of the tow depends on the purpose of the trawl, the catch rate, and the target species. Commercial trawl vessels may travel at speeds between two and five knots while towing the net for up to several hours, whereas the majority of NWFSC trawl surveys involve tow speeds from 1.5 to 3.5 knots and tow durations from 10 to 30 minutes. For research purposes, the speed and duration of the tow and the characteristics of the net must be standardized to allow meaningful comparisons of data collected at different times and locations. Active acoustic devices incorporated into the research vessel and the trawl gear monitor the position and status of the net, speed of the tow, and other variables important to the research design. At the end of the tow, the net is retrieved and the contents of the codend are emptied onto the deck or sorting table.

Some NWFSC research surveys use “pelagic” trawls, which are designed to operate either near the surface or at various depths within the water column, and other surveys use “bottom” trawls (see Table 2.2-1 in the DPEA for survey protocol and net details). Examples of NWFSC trawl gear fished at the surface include the Nordic 264, Kodiak surface trawl, and paired surface trawls. Examples of NWFSC trawl gear fished lower in the water column include the Modified Cobb mid-water trawl and the Aleutian wing mid-water trawl. Pelagic trawl nets are not designed to contact the seafloor and do not have bobbins or roller gear on the footrope. Bottom trawl nets have footropes with rollers or other groundgear designed for particular sea floor conditions to maximize the capture of target species living close to the bottom and minimize damage to the gear while moving across uneven surfaces (Figure A-1). Examples of NWFSC bottom trawl nets include the modified Aberdeen trawl, Poly Nor’easter trawl, paired shrimp trawl, and beam trawls

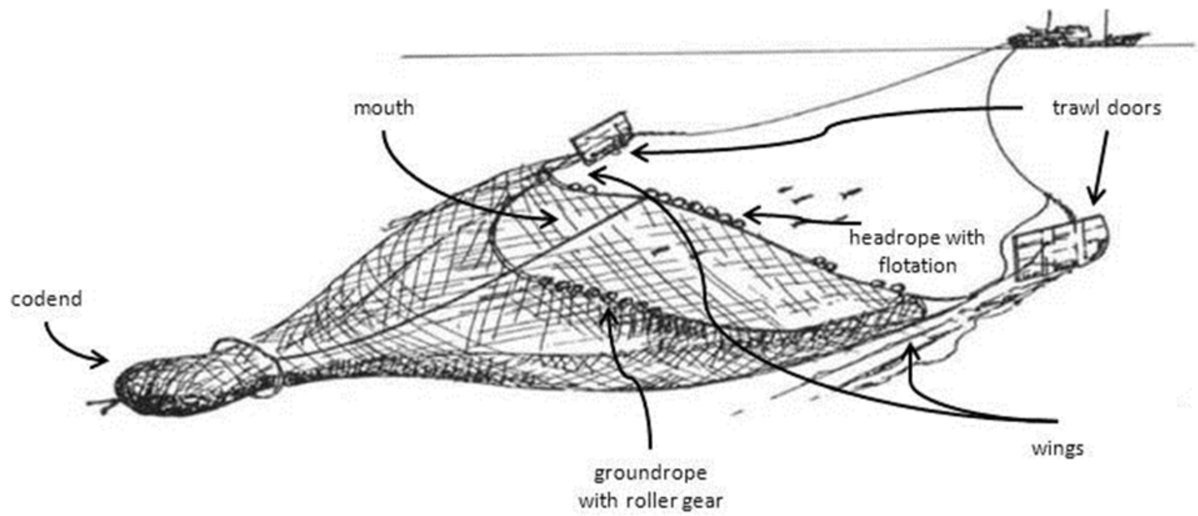


Figure A-1. Bottom trawl illustration

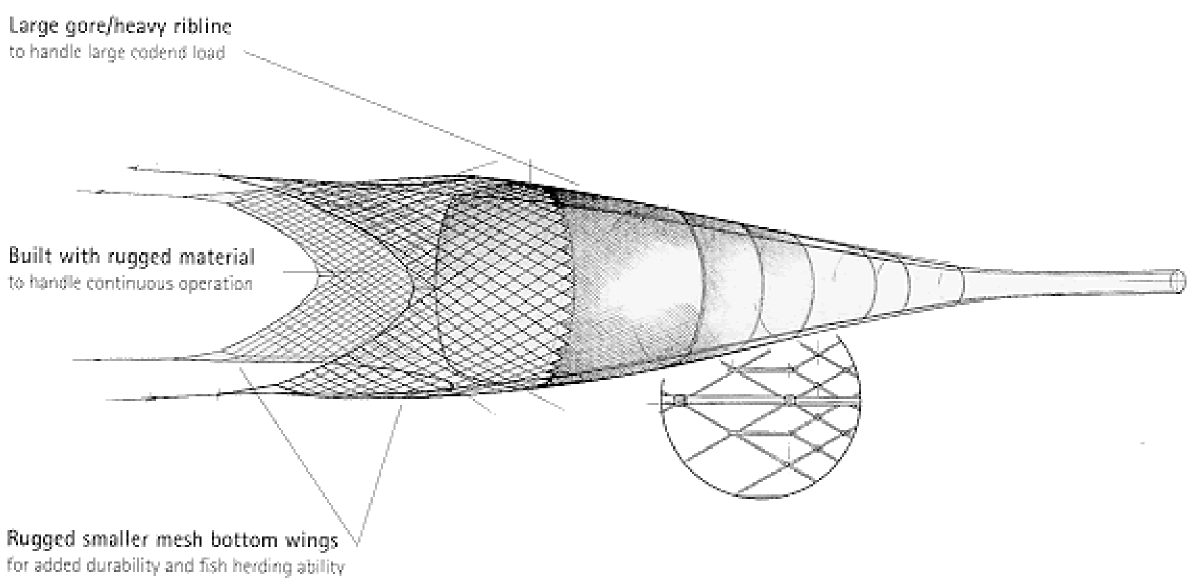


Figure A-2. Aleutian wing trawl illustration

Figure A-3.   Beam trawl illustration

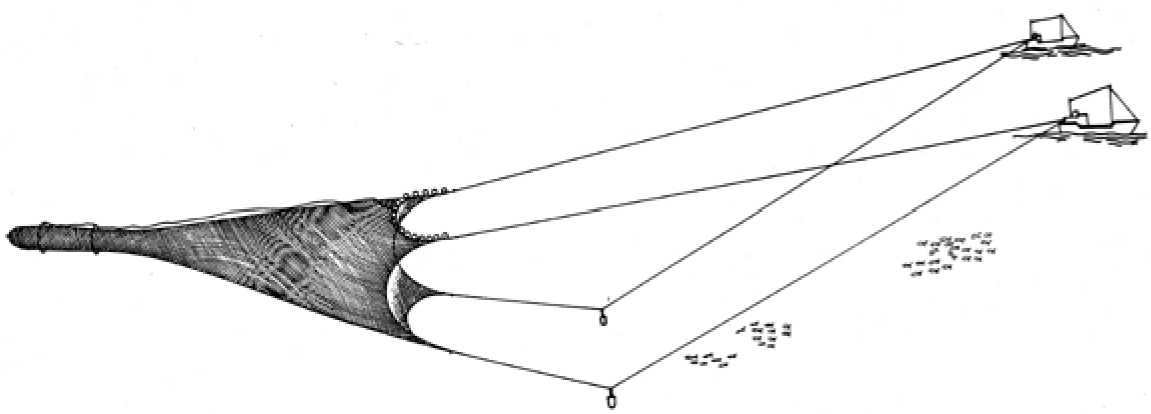


Figure A-4.   Pair trawl illustration

Most NWFSC research trawlers employ a single trawl net to catch fish. The Bycatch Reduction Research Survey uses a double rigged trawl. In this method, the vessel tows two small trawl nets simultaneously rather than a single large one.

Marine mammals can become entangled by trawl gear with risks differing widely among species. Many species of marine mammals forage and swim at mid-water depths and all species come to the surface to breathe and rest, putting them at risk of being captured or entangled in pelagic trawls. Species that forage on or near the seafloor are at risk of being captured or entangled in bottom trawl netting or tow lines. There is also potential for marine mammals to interact with bottom trawl equipment near the surface of the water, as the gear is retrieved from fishing depth and brought aboard the vessel.

Recently, considerable effort has been made to develop excluder devices that allow marine mammals to escape from the net while allowing retention of the target species (e.g. Dotson et al. 2010). Marine mammal excluder devices (MMEDs) generally consist of a large rigid grate positioned in the intermediate portion of the net forward of the codend and above or below an “escape panel” constructed into the net panel (Figure A-5). The angled grate is intended to guide marine mammals through the escape panel and prevent them from being caught in the codend (Dotson et al. 2010). Different configurations of MMEDs are currently being tested on Nordic 264 nets used in the PNW Juvenile Salmon Survey.

Several NWFSC surveys use trawls with an open codend. These surveys have a reduced impact to marine organisms because they use equipment to detect or record target species and eliminate the need to capture organisms. The Pair Trawl Columbia River Juvenile Salmon Survey uses a surface pair trawl with an open codend equipped with a passive integrated transponder (PIT) detector array (discussed in detail in Section 12) to assess the passage of tagged juvenile salmon migrating from the Columbia River basin to the ocean. Another survey uses a 2-meter beam trawl with a digital video camera system (discussed further in Section 13). The trawl has an open codend and the video camera documents what goes into the net since there is no catch. A different survey also uses a 2-meter beam trawl with a video camera. In this survey, the beam trawl primarily has an open codend but a few tows are conducted with a closed codend to verify species composition identified in the video.

(Dotson et al. 2010)

Figure A-5. Marine Mammal Excluder Device installed in Nordic 264 pelagic trawl net.

2. Plankton nets

NWFSC research activities include the use of several plankton sampling nets which employ very fine mesh to sample plankton from various parts of the water column. NWFSC plankton nets employ mesh sizes from 20 to 500 micrometers. Plankton sampling nets usually consist of fine mesh attached to a rigid frame. The frame spreads the mouth of the net to cover a known surface area. Many plankton nets have a removable collection container at the codend where the sample is concentrated. When the net is retrieved, the collecting bucket can be detached and easily transported to a laboratory. Plankton nets may be towed through the water horizontally, vertically, or at an oblique angle. Often, plankton nets are equipped with instruments such as flow meters or pitch sensors to provide researchers with additional information about the tow or to ensure plankton nets are deployed consistently.

To capture plankton with vertical tows, the NWFSC uses ring nets. A ring net consists of a circular frame and a cone-shaped net with a collection jar at the codend. The net, attached to a labeled dropline, is lowered into the water while maintaining the net's vertical position. When the desired depth is reached, the net is pulled straight up through the water column to collect the sample.

A bongo net (Figure A-6) looks like two ring nets whose frames are yoked together and allows replicate samples to be collected concurrently. Bongo nets are towed through the water at an oblique angle to sample plankton over a range of depths. During each plankton tow, the bongo net is deployed to the desired depth and is then retrieved at a controlled rate so that the volume of water sampled is uniform across the range of depths. In shallow areas, sampling protocol is adjusted to prevent contact between the bongo nets and the seafloor. A collecting bucket, attached to the codend of the net, is used to contain the plankton sample. Some bongo nets can be opened and closed with remote control to enable the collection of samples from particular depth ranges. A group of depth-specific bongo net samples can be used to establish the vertical distribution of zooplankton species in the water column at a site.

Credit: Morgan Busby, Alaska Fisheries Science Center

Figure A-6. Bongo net

The Tucker net is a medium-sized single-warp trawl net used to capture plankton at different depths. The Tucker trawl usually consists of a series of nets that can be opened and closed sequentially without retrieving the net from the fishing depth.

Neuston nets are designed to capture members of the neuston, the collective term for the organisms that inhabit the water's surface. Neuston nets have a rectangular frame and are towed horizontally at the top of the water column.

3. Epibenthic tow sled

An epibenthic tow sled is an instrument that is designed to collect organisms that live on bottom sediments (Figure A-7). It consists of a fine mesh net attached to a rigid frame with runners to help it move along the substrate. The sled is towed along the bottom at the sediment-water interface, scooping up benthic organisms as it goes. NWFSC uses an epibenthic tow sled with a 1 meter by 1 meter opening and 1-millimeter mesh to collect epibenthic invertebrates in shallow eelgrass beds in Central Puget Sound.

Credit: University of South Carolina

Figure A-7. Epibenthic tow sled

4. Seine nets

A seine is a fishing net that generally hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. NWFSC uses several types of seines including purse seines, beach seines, and pole seines. A purse seine is a large wall of netting deployed around an entire area or school of fish. A purse seine has rings along the bottom of the net through which a drawstring cable is threaded. Once a school of fish is located, the vessel encircles the school with the net. The cable is then pulled in, ‘pursing’ the net closed on the bottom, preventing fish from escaping by swimming downward (Figure A-8). The catch is harvested by either hauling the net aboard or bringing it alongside the vessel. Purse seines can reach more than 6,500 feet in length and 650 feet in depth, varying in size according to vessel, mesh size, and target species (NOAA Fisheries 2014). The purse seines employed by NWFSC are between 500 and 1,500 feet in length, between 30 and 90 feet in depth, and have mesh sizes ranging from 0.45 inches to 1.3 inches depending on the location in the net.

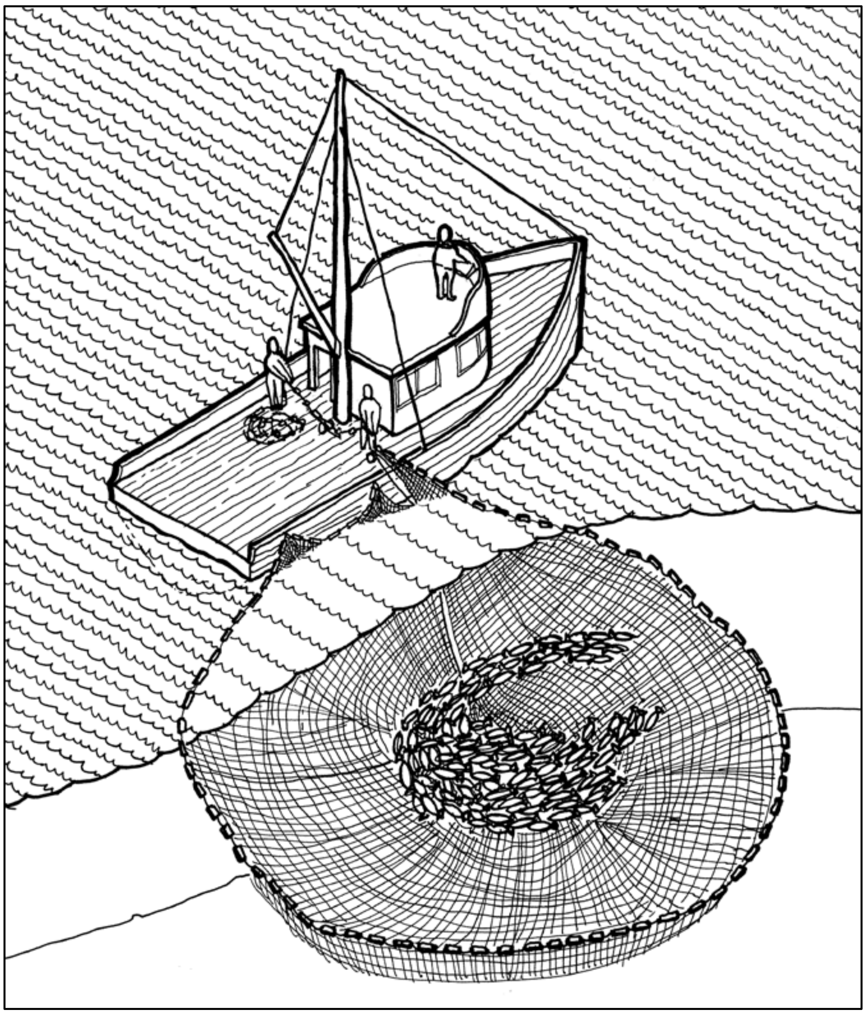


Figure A-8. Purse seine illustration

Beach seines are deployed from shore to surround all fish in a nearshore area. When setting the net, one end is fastened to the shore while the other end is set out in a wide arc and brought back to the beach. A beach seine can be deployed by hand or with the help of a small boat. When the net is set, each side is pulled in simultaneously, herding the fish toward the beach (Figure A-9). During the entire operation, the headrope with floats stays on the surface and the weighted footrope remains in contact with the bottom to prevent fish from escaping the area enclosed by the net. The beach seines used in NWFSC research are 6 to 8 feet in depth and 120 to 150 feet in length, with mesh sizes of less than 1 inch.

Credit: Paul Olsen, NOAA Fisheries

Figure A-9. A beach seine being pulled in

A pole seine is a rectangular net that has a pole on either end to keep the net rigid and act as a handle for pulling the net in (Figure A-10). The net is pulled along the bottom by hand as two or more people hold the poles and walk through the water. Fish and other organisms are captured by walking the net towards shore or tilting the poles backwards and lifting the net out of the water. The pole seine used by NWFSC is 40 feet long, 6 feet tall, and has mesh smaller than 1 inch.

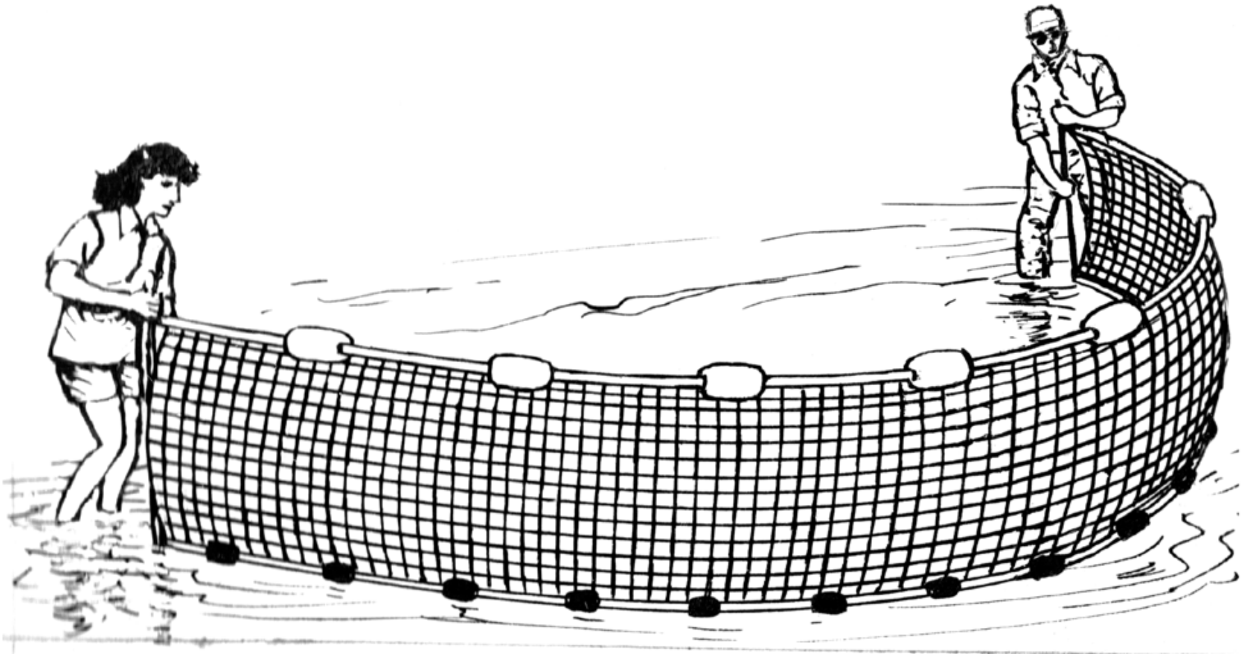


Figure A-10. Pole seine

5. Tangle net

Tangle nets are vertical panels of nylon netting and are normally set in a straight line (Figure A-11). The top of the net is buoyed with floats and the bottom of the net is weighted to maintain the net's vertical position. Tangle nets are designed for non-lethal capture of fish. The smaller mesh of a tangle net prevents fish from entering the net beyond the operculum (gill cover); instead, fish are caught by the nose or jaw. This allows fish to continue respiring and reduces their risk of injury. NWFSC uses a 600- by 40-foot tangle net with 4.25-inch mesh to catch adult salmon in the Columbia River Estuary.

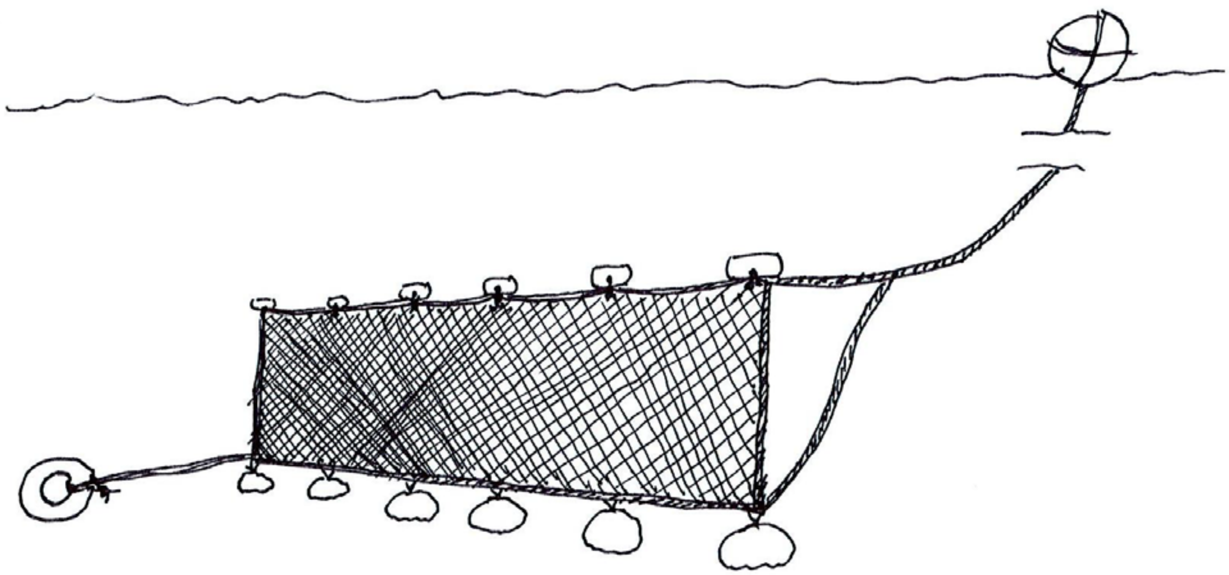


Figure A-11. Diagram of a tangle net, shown upright

6. Fish traps and pots

Fishing pots and traps are three-dimensional structures that permit fish and other organisms to enter the enclosure but make it difficult for them to escape. Traps and pots allow commercial fishers and researchers to capture live fish and can allow them to return bycatch to the water unharmed. Traps and pots also allow some control over species and sizes of fish that are caught. The trap entrance can be regulated to control the maximum size of fish that enter. The size of the mesh in the body of the trap can regulate the minimum size that is retained. In general, the fish species caught depend on the type and characteristics of the pot or trap used. Fishing traps and pots used by NWFSC include fyke traps and sablefish pots. A fyke trap consists of a trap or bag that can be conical, cylindrical, rectangular, or a floating box that are held open by frames or hoops (Figure A-12). Fyke traps are often outfitted with wings and/or leaders to guide fish towards the entrance of the actual trap. NWFSC sets fyke traps with 0.25-inch mesh for up to 6 hours in the Snohomish and Columbia river estuaries. Fyke nets are used in estuarine wetland types of habitats. The NWFSC traps channels that range in width from less than 3 ft to 15 ft. Fyke trap wings can be set up to form a barrier across a channel, trapping fish that attempt to proceed through the channel. As the tide ebbs, fish eventually seek to leave the wetland channel and are then trapped. A fyke trap is fixed on the bottom with anchors or stakes or sand bags. Usually the wings and mouth of the trap float or stick out of the water so fish cannot evade capture by swimming over the trap.

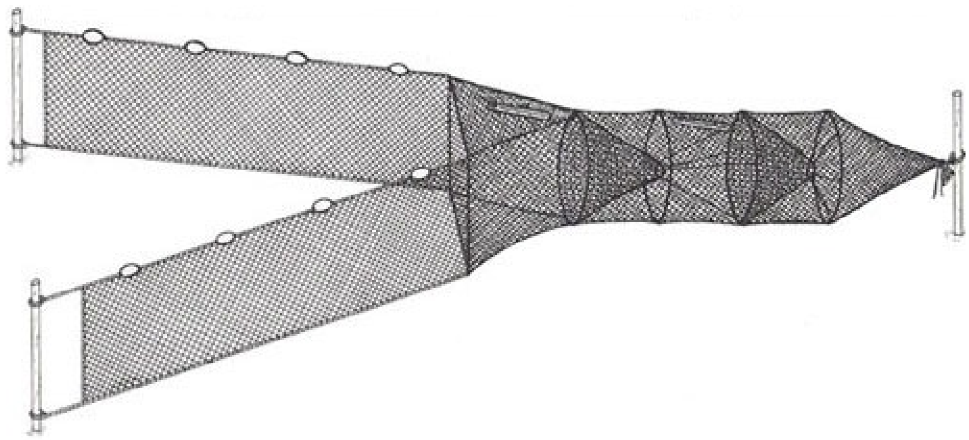


Figure A-12. Fyke trap

The NWFSC employs a limited number of conical sablefish pots (Figure A-13) to catch fish for broodstock. These pots consist of a conical-frustum-shaped frame covered in nylon netting with one or more funnel-shaped entrance tunnels. The sablefish pots used by NWFSC are 4 feet in diameter, have a soak time of 8 hours, and they are baited with squid and herring to lure fish into the pots. Sablefish pots rest on the seafloor and are often attached by a rope to a buoy at the water's surface. If a series of pots is set, a groundline may be used to connect the pots to each other to aid in pot deployment and retrieval. Modified sablefish pots are also used as predator exclusion cages for the Herring Egg Mortality Survey in Puget Sound.

Figure A-13. Illustration of a conical sablefish pot

7. Insect traps and benthic corers

As part of the Columbia River Estuary Tidal Habitats survey, NWFSC uses insect fallout traps, emergent insect cone traps, and benthic corers to sample invertebrate prey items potentially available to juvenile salmon. Insect fallout traps measure the quantity and diversity of wetland insects falling on the surface of the water. An insect fallout trap consists of a plastic box filled approximately halfway with soapy water. The containers used by NWFSC measure 50 by 35 by 14 centimeters and have a less than 10 percent dish soap solution. The containers are surrounded by four stakes to prevent the trap from floating away while allowing it to float vertically with the tides (Roegner et al. 2004).

Emergent insect cone traps are designed to capture insects as they metamorphose from aquatic nymph to terrestrial adult. The traps used by NWFSC look like inverted plastic funnels with a collection container attached to the top to contain the emerged insects (Figure A-14). Each trap is anchored in the water and collects all insects that emerge in the 0.6-m^2 area directly below the mouth of the funnel.

Benthic corers are used to collect sediment and associated benthic invertebrate samples (Figure A-14). A common type of benthic corer consists of a plastic cylinder that is pressed vertically into the sediment. Then the corer has been inserted far enough into the substrate, the top of the cylinder is capped and the corer along with the sediment sample can be pulled out far enough to cap the bottom of the tube. The corer used by NWFSC collects a sample with a 0.0024-m^2 surface area.

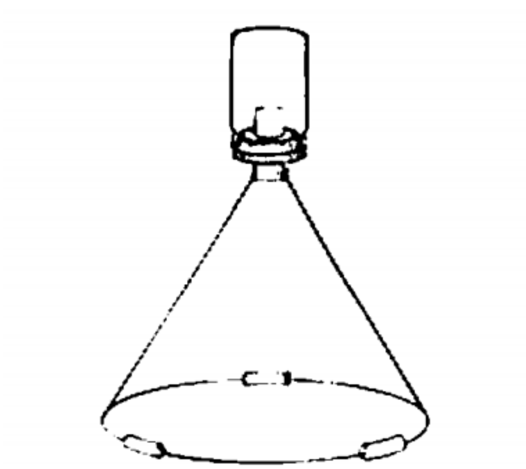


Figure A-14. An illustration of an emergent insect cone trap (left) and an example of a benthic corer with a sediment sample (right)

8. Hook-and-line Gear

Under the Status Quo, the NWFSC used rod and reel hook-and-line gear for the Southern California Groundfish Surveys that occurred within untrawlable areas. Under the Preferred Alternative, that project has been expanded to occur all along the West Coast and has been renamed, “Coastwide Groundfish Hook and Line Survey in Untrawlable Habitat”. Hook-and-line gear deployed from rod and reel was also used for fish movement studies in Puget Sound on sixgill shark, Chinook and Coho salmon as well as lingcod. Barbed or barbless circle hooks are used depending on the needs of the research to retain or release fish with minimal injury (Figure A-15).

Figure A-15. Barbed and barbless circle hooks

Longline fishing is a type of hook-and-line gear in which baited hooks attached to a mainline or 'groundline' are deployed from a vessel (Figure A-16). The length of the longline and the number of hooks depend on the species targeted, the size of the vessel used, and the purpose of the fishing activity. Commercial longlines can be over 100 kilometers long and can have thousands of hooks attached, however longlines used for research purposes are much shorter. The longline gear NWFSC uses for collection of fish for broodstock consists of 500 hooks attached to a mainline approximately 750-1000 fathoms in length. Hooks are attached to the longline by thinner lines called a 'gangions.' The length of the gangions and the distance between each gangion depends on the purpose of the research. For NWFSC broodstock collection, the gangions are less than one foot in length and are attached to the mainline at intervals of about 10 feet.

Longline research gear can be deployed either suspended in the water column with floats (pelagic gear) or anchored to the bottom (Figure A-16) with the hooks either resting on the bottom or floating just above the seafloor (demersal gear). The NWFSC uses pelagic gear in the CCRA and demersal gear in the PSRA. Demersal longline gear has weights to hold the mainline down and buoys to provide flotation and keep the baited hooks suspended in the water. Flag buoys (or 'high flyers') equipped with radar reflectors, radio transmitters, and/or light sources are often attached to each end of the mainline to enable the crew to find the longline gear for retrieval.

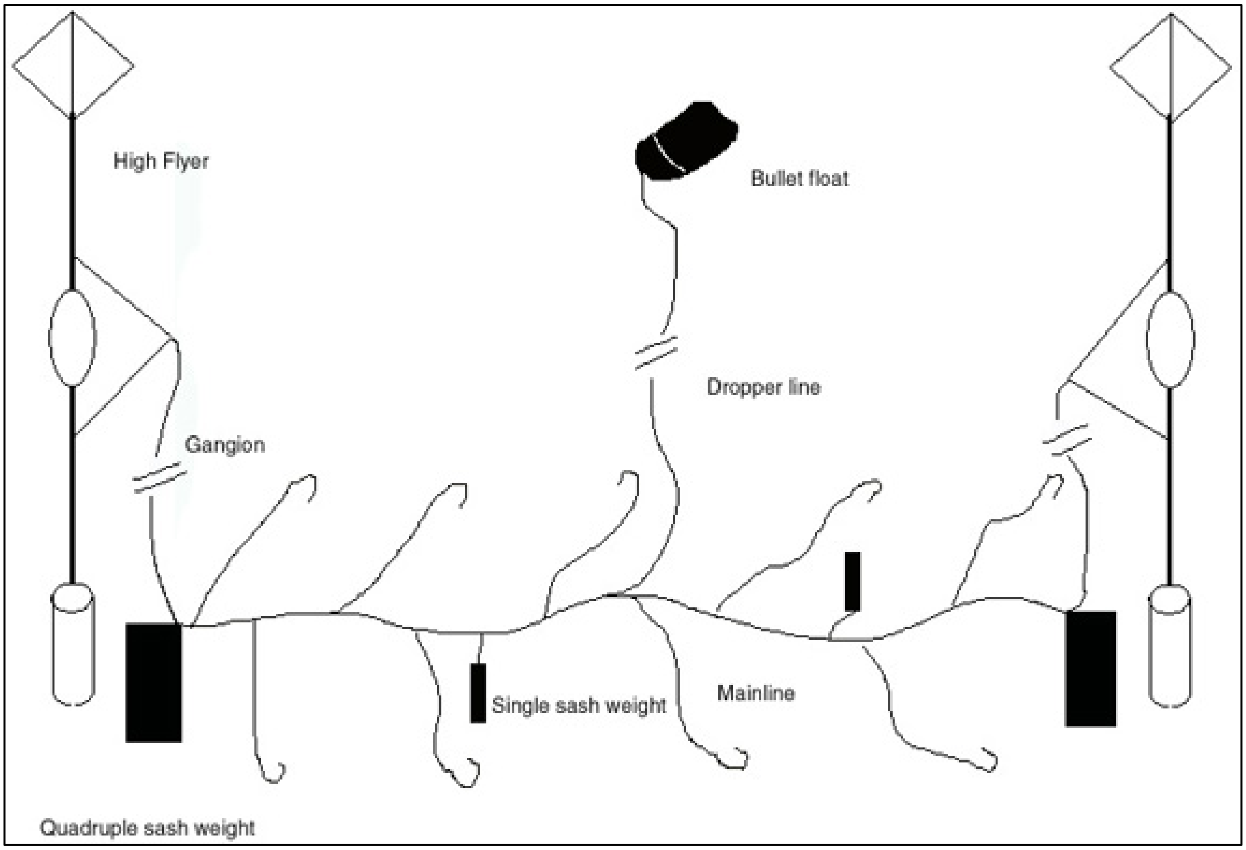


Figure A-16. Schematic example of bottom longline gear.

The time between deployment and retrieval of the longline gear is the ‘soak time.’ Soak time is an important parameter for calculating fishing effort and may be an important part of the research protocol. The optimal soak time maximizes the catch of target species while minimizing bycatch and minimizing damage to hooked target fish that may result from sharks or other predators. Soak time can also be an important factor for controlling longline interactions with protected species. Marine mammals, turtles, and other protected species may be attracted to bait, or to fish caught on the longline hooks. Protected species may become caught on longline hooks or entangled in the longline while attempting to feed on the catch before the longline is retrieved.

Birds may be attracted to the baited longline hooks, particularly while the longline gear is being deployed from the vessel. Birds may get caught on the hooks, or entangled in the gangions while trying to feed on the bait. Birds may also interact with longline gear as the gear is retrieved.

9. Electrofishing

Electrofishing is a common scientific survey method that uses electricity to momentarily stun fish or force them to involuntarily swim towards an electrical field to make them easier to capture. This method is used to sample fish populations to determine abundance, density, and species composition. NWFSC researchers use both backpack electrofishing units (Figure A-17) and boat-based electrofishing to collect fish. Both types of electrofishing use a power source to create electrical currents that flow from the positive electrode (anode) through the water to the negative electrode (cathode). When stunned fish are immobilized or move toward the anode, they are quickly captured with a dip net and placed in a bucket or holding tank. The fish can then be identified, measured, and released. Electrofishing does not result in permanent harm to the fish, which recover within a few minutes.

Credit: NOAA Fisheries West Coast Region

Figure A-17. A backpack electrofishing crew.

The person on the left is operating the backpack electroshocker and holding the anode in the water. The person on the right is using a dip net to collect stunned fish.

10. Active Acoustic Sources used in NWFSC Fisheries Surveys

A wide range of active acoustic sources are used in NWFSC fisheries surveys for remotely sensing bathymetric, oceanographic, and biological features of the environment, Most of these sources involve relatively high frequency, directional, and brief repeated signals tuned to provide sufficient focus and resolution on specific objects. Table A-1 shows important characteristics of these sources used on NOAA research vessels conducting NWFSC fisheries surveys, followed by descriptions of some of the primary general categories of sources, including all those for which acoustic takes of marine mammals are calculated in the LOA application.

Table A-1. Output Characteristics for Predominant NWFSC Acoustic Sources

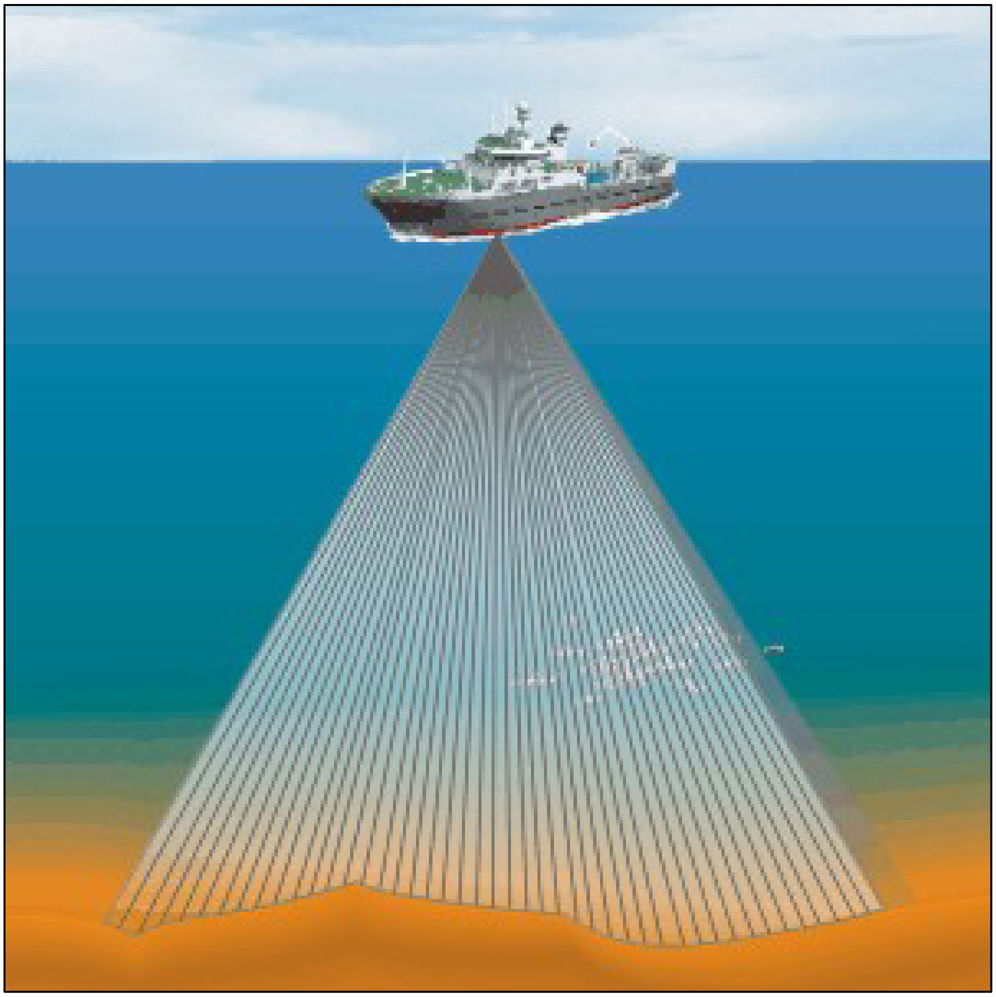
Abbreviations: kHz = kilohertz; dB re 1 µPa at 1 m = decibels referenced at one micro Pascal at one meter; ms = millisecond; Hz = hertz

Acoustic system	Operating frequencies (kHz)	Maximum source level (dB re 1 µPa at 1 m)	Single ping duration (ms) and repetition rate (Hz)	Orientation/ Directionality	Nominal beam width (degrees)
Simrad EK60 narrow beam echosounder	18, 38, 70, 120, 200 kHz	224	1 ms @ 1 Hz	Downward looking	11°
Simrad ME70 multibeam echosounder	70-120 kHz	205	2 ms @ 1 Hz	Downward looking	140°
RDI ADCP Ocean Surveyor	75 kHz	223.6	External trigger	Downward looking (30° tilt)	40° x 100°
Simrad ITI trawl monitoring system	27-33 kHz	<200	0.05-0.5 Hz	Downward looking	40° x 100°
Simrad FS70 trawl sonar	330 kHz	216	1 ms @ 120 kHz	Third wire trawl sonar for monitoring net opening and fishing conditions	5° x 20°
Simrad SX90 omni-directional multibeam sonar	70-120 kHz	206	2 ms @ 1 Hz	Downward omni-directional	0°-90° tilt angle from vertical (average)

Multibeam echosounder and sonar

Multibeam echosounders (Figure A-18) and sonars work by transmitting acoustic pulses into the water then measuring the time required for the pulses to reflect and return to the receiver and the angle of the reflected signal. The depth and position of the reflecting surface can be determined from this information, provided that the speed of sound in water can be accurately calculated for the entire signal path.

The use of multiple acoustic ‘beams’ allows coverage of a greater area compared to single beam sonar. The sensor arrays for multibeam echosounders and sonars are usually mounted on the keel of the vessel and have the ability to look horizontally in the water column as well as straight down. Multibeam echosounders and sonars are used for mapping seafloor bathymetry, estimating fish biomass, characterizing fish schools, and studying fish behavior. This gear generally emits frequencies from 38 to 200 kHz at less than 228 dB/1 µPa.



Credit: Simrad

Figure A-18. Conceptual image of a multibeam echosounder

Multi-frequency single-beam active acoustics

Similar to multibeam echosounders, multi-frequency split-beam sensors are deployed from NOAA survey vessels to acoustically map the distributions and estimate the abundances and biomasses of many types of fish; characterize their biotic and abiotic environments; investigate ecological linkages; and gather information about their schooling behavior, migration patterns, and avoidance reactions to the survey vessel. The use of multiple frequencies allows coverage of a broad range of marine acoustic survey activity, ranging from studies of small plankton to large fish schools in a variety of environments from shallow coastal waters to deep ocean basins. Simultaneous use of several discrete echosounder frequencies facilitates accurate estimates of the size of individual fish, and can be used for species identification based on differences in frequency-dependent acoustic backscattering between species. The NWFSC uses devices that transmit and receive at four frequencies ranging from 30 to 200 kHz.

ADCP

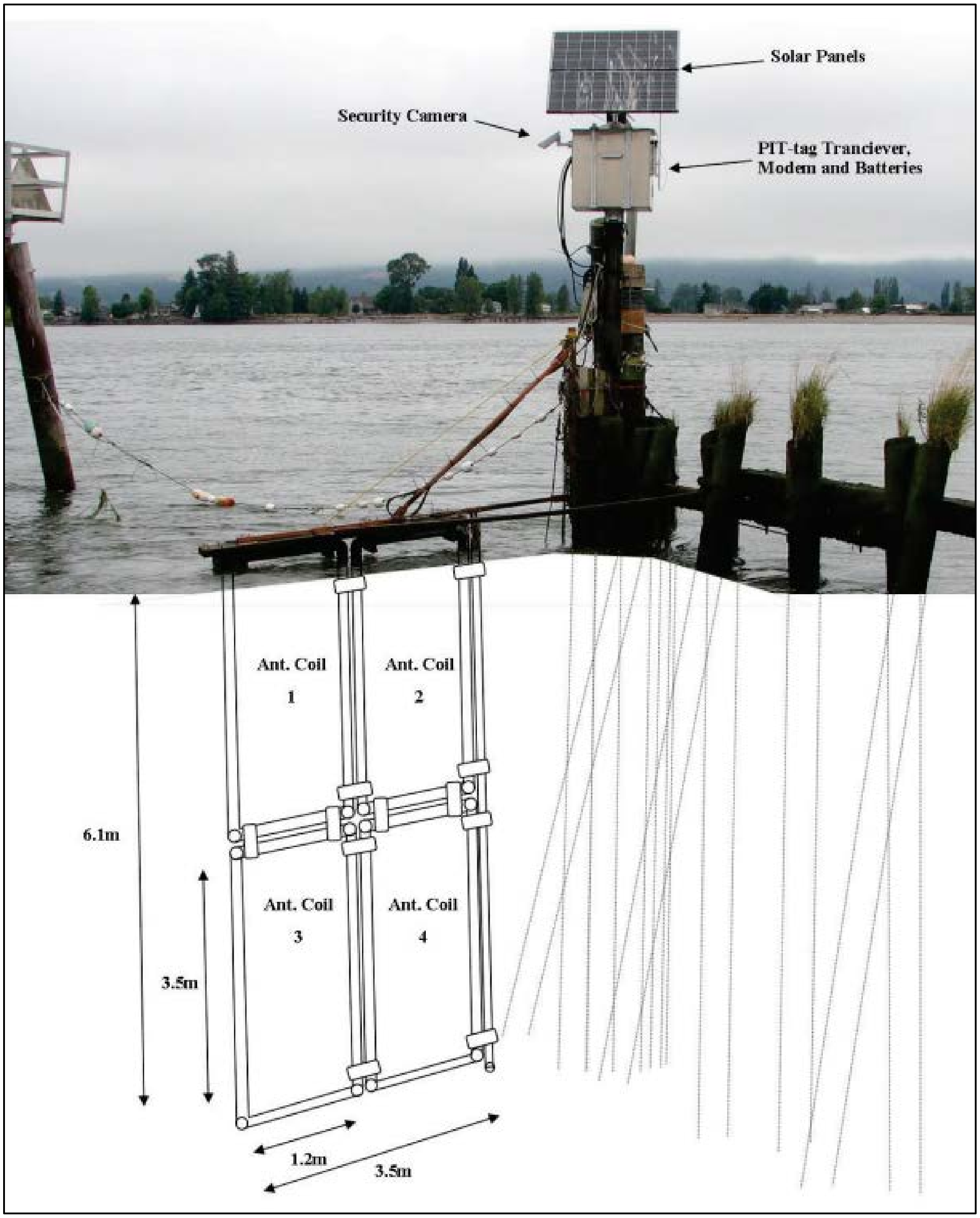
An Acoustic Doppler Current Profiler (ADCP) is a type of sonar used for measuring water current velocities simultaneously at a range of depths. An ADCP instrument can be mounted to a mooring or to the bottom of a boat. The ADCP works by transmitting "pings" of sound at a constant frequency into the water. As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument (WHOI 2011). Sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return and particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving. Sound waves that hit particles far from the profiler take longer to come back than waves that strike close by. By measuring the time it takes for the waves to return to the sensor, and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings (WHOI 2011).

11. Acoustic telemetry

Acoustic telemetry for fisheries research employs acoustic tags which are small, sound-emitting devices allowing the detection of fish or aquatic invertebrates. An acoustic tag, or transmitter, is an electronic device usually implanted or externally attached to an aquatic organism. A tag transmits short ultrasonic signals (typically 69 kHz) either at regular intervals or as a series of several pings that contain a digital identifier code (which allows researchers to identify individual fish) and sometimes physical data (e.g., temperature). An acoustic receiver detects and decodes transmissions from acoustic tags. NWFSC uses Vemco VR2 receivers moored in fixed locations to detect the presence or absence of coded tags. For the Effects of Dredging on Crab Recruitment survey, NWFSC uses V9-2H transmitters to track Dungeness crab movements. These tags have a battery life of 100 to 280 days.

12. PIT tags and antennas

The passive integrated transponder (PIT) is a type of radio frequency identification used extensively in fisheries research. A PIT tag consists of an integrated circuit chip, capacitor, and antenna coil encased in glass. PIT tags vary in size and shape depending on the study animal. Generally, tags are cylindrical in shape, about 8-32 mm long, and 1-4 mm in diameter. PIT tags can be inserted in fish or other organisms via large-gauge hypodermic needles. Unlike acoustic tags (described in Section 13), PIT tags are dormant until activated and do not require an internal source of power. To activate the tag, a low-frequency radio signal is emitted by a scanning device that generates a close-range electromagnetic field. The tag then sends a unique alpha-numeric code back to the reader, allowing researchers to identify specific individuals (Smyth and Nebel 2013). NWFSC uses stationary PIT detection antennas in the Columbia River Estuary to detect migrating adult and juvenile salmon (Figure A-19). NWFSC also uses a PIT detector array attached to a surface pair trawl with an open codend (described in Section 1) which is towed at a depth of 5 meters for 8 to 15 hours at a speed of 1.5 knots in the Columbia River Estuary to assess the passage of migrating juvenile salmon.



Credit: NWFSC

Figure A-19. Configuration of antennas for a PIT tag detector on a pile dyke in the Columbia River Estuary

13. Video cameras

The NWFSC uses several apparatuses to collect underwater videos of benthic habitats and organisms. These include a CamPod, a video camera sled, video beam trawls, and a remotely operated vehicle

(ROV). Each apparatus includes a video camera system consisting of a digital video camera, lights, and a power source. The CamPod (Figure A-20) is a lightweight, three-legged platform equipped with a video system and adequate illumination. The frame holds a 35-millimeter stills camera system and two video cameras – one that provides a forward-looking oblique view and a high-resolution video camera that faces downward. Designed primarily for making images of the benthic environment, the configuration of the device focuses on minimizing its hydrodynamic presence in the field of view of the cameras. The CamPod is deployed vertically through the water column on a cable and is intended to view one point on the bottom.

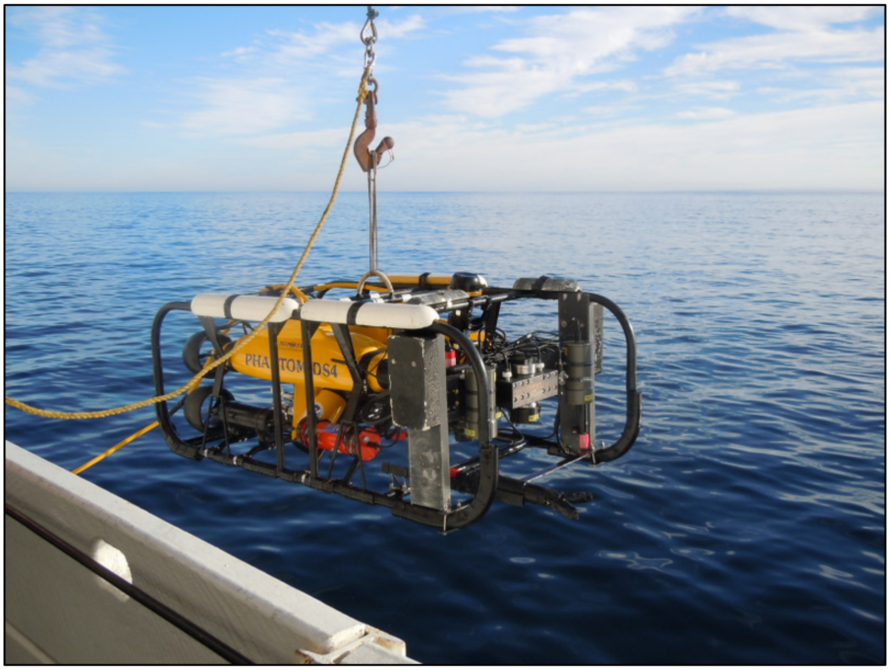
Credit: Northwest Atlantic Fisheries Organization

Figure A-20. A CamPod being deployed from a vessel

A video camera sled consists of a video camera system mounted on a metal frame with runners to allow it to move along the benthic substrate. A research vessel tows the sled along the seafloor, allowing the camera to capture video footage of the benthic environment.

The video beam trawls used by NWFSC are similar to video camera sleds. Video beam trawls consist of a video camera system attached to a beam trawl (described in Section 1) which is towed along the seafloor at speeds of 1 to 1.5 knots. NWFSC uses video beam trawls to assess the seasonal and interannual distribution of young of the year groundfishes as well as the potential effects of hypoxia on groundfish.

NWFSC uses a video ROV (Figure A-21) to capture underwater footage of the benthic environment. The ROV is controlled and powered from a surface vessel. Electrical power is supplied through an umbilical or tether which also has fiber optics which carry video and data signals between the operator and the ROV. This enables researchers on the vessel to control the ROV’s position in the water with joysticks while they view the video feed on a monitor.



Credit: Southwest Fisheries Science Center

Figure A-21. A remotely operated vehicle (ROV) being deployed from a vessel

14. CTD profiler and rosette water sampler

‘CTD’ stands for conductivity, temperature, and depth. A CTD profiler measures these and other parameters, and is the primary research tool for determining chemical and physical properties of seawater. A shipboard CTD is made up of a set of small probes attached to a large (1 to 2 meters in diameter) metal rosette wheel (Figure A-22). The rosette is lowered through the water column on a cable, and CTD data are observed in real time via a conducting cable connecting the CTD to a computer on the vessel. The rosette also holds a series of sampling bottles that can be triggered to close at different depths in order to collect a suite of water samples that can be used to determine additional properties of the water over the depth of the CTD cast. The duration of a CTD cast varies depending on water depth. The data collected at different depths are often called a depth profile, and are plotted with the value of the variable of interest on the x-axis and the water depth on the y-axis. Depth profiles for different variables can be compared in order to glean information about physical, chemical, and biological processes occurring in the water column.

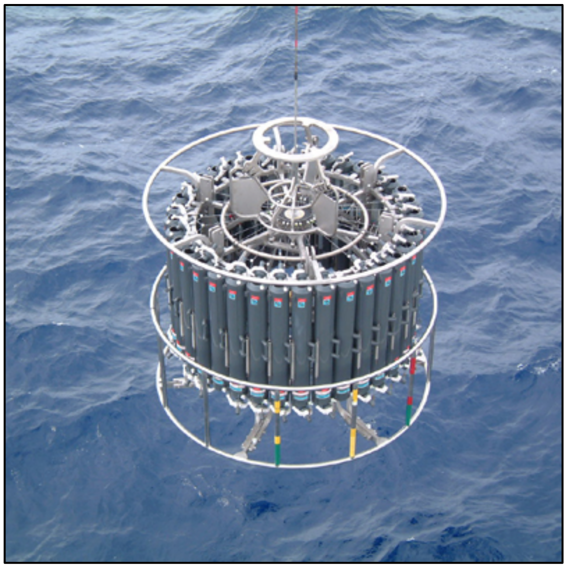


Figure A-22. Sea-Bird 911 plus CTD profiler (left) and CTD profiler deployment on a sampling rosette (right)

Conductivity is measured as a proxy for salinity, or the concentration of salts dissolved in seawater. Salinity is expressed in 'practical salinity units' which represent the sum of the concentrations of several different ions. Salinity is calculated from measurements of conductivity. Salinity influences the types of organisms that live in a body of water, as well as physical properties of the water. For instance, salinity influences the density and freezing point of seawater.

Temperature is generally measured using a high-sensitivity thermistor protected inside a thin walled stainless steel tube. The resistance across the thermistor is measured as the CTD profiler is lowered through the water column to give a continuous profile of the water temperature at all water depths.

The depth of the CTD sensor array is continuously monitored using a very sensitive electronic pressure sensor. Salinity, temperature, and depth data measured by the CTD instrument are essential for characterization of seawater properties. CTD profilers can be outfitted with instruments such as fluorometers, transmissometers, and dissolved oxygen sensors to measure additional water quality parameters. A fluorometer measures fluorescence and can be used to detect chlorophyll-a concentrations, an indicator of phytoplankton biomass. A transmissometer measures the transmission of light through water, which is essential to the productivity of oceans. Transmittance is reduced when light is scattered and absorbed by suspended particles, phytoplankton, bacteria, and dissolved organic matter. Dissolved oxygen sensors measure the amount of oxygen gas that is dissolved in seawater. Dissolved oxygen affects ocean chemistry and is essential for many marine organisms such as fish and invertebrates. Dissolved oxygen concentrations are impacted by environmental conditions such as temperature, salinity, turbidity, and plankton blooms.

15. Thermosalinograph and water pump, water level and temperature loggers

The CTD is not the only tool NWFSC uses to collect water quality parameters. Onboard the research vessel for the Juvenile Salmon Pacific Northwest Coastal Survey, NWFSC uses a continuous water pump with an SBE-45 MicroTSG thermosalinograph to measure sea surface conductivity and temperature. The pump continuously pumps seawater from a depth of 3 meters near the bow of the research vessel to the thermosalinograph which sends the temperature and conductivity data to a shipboard computer. The importance of conductivity and temperature measurements is described in Section 14.

To collect physical environmental data in riverine and estuarine habitats, NWFSC uses water level and temperature loggers. These devices are placed underwater at fixed locations where they continuously record data. NWFSC uses a 3 by 4 centimeter device called a TidbiT to measure and record water temperatures. To log water levels, NWFSC uses a Hobo U-model water level data logger. These devices record measurements at user defined intervals and generally have the memory and battery power to record thousands of measurements over several years.

16. NWFSC Vessels used for Survey Activities

NMFS employs NOAA-operated research vessels, chartered vessels, and vessels operated by cooperating agencies and institutions to conduct research, depending on the survey and type of research.

Figure A-23. R/V *Bell M. Shimada*

New to NOAA in 2010, the R/V *Bell M. Shimada* (Figure A-23) is one of the most technologically advanced fisheries vessels in the world. Many of the advances are focused on making the boat quieter and reducing disturbance to marine life. The vessel is fourth in the series of new fisheries survey vessels built for NOAA by VT Halter Marine, Inc. R/V *Bell M. Shimada* is home ported in Newport, OR and is shared by the SWFSC and the NWFSC. The vessel is 209 feet in length with a diesel electric drive system with two 1,508-horsepower propulsion motors and one 14.1-foot propeller. The deck has an oceanographic winch, two stern trawl winches, and two A-Frame winches. The ship can cruise at 12 knots. The R/V *Bell M. Shimada* can accommodate 39 crewmembers, including 15 scientists. The technologies on the boat offer scientists the ability to monitor fish populations without altering their behavior, allowing accurate data collection.

Figure A-24. R/V *Pelican*

The R/V *Pelican* (Figure A-24) is a 39-foot aluminum pontoon boat owned by NWFSC and is specifically designed for purse seining. It has a pilothouse, a flat back deck, and mast and boom for purse seining. There are no rails on the starboard side to facilitate deployment of the purse seine. The vessel is propelled by an inboard gas engine and has a separate gas engine, surface mounted on the aft port side, to run the water system as well as the hydraulics for the purse seine winch. R/V *Pelican* and accompanying skiff, R/V *Tule*, are used exclusively for studying salmon habitat-use in the Lower Columbia River estuary.

Credit: NOAA

Figure A-25. R/V *Noctiluca*

The R/V *Noctiluca* is a 26-foot NMFS vessel with a center console (Figure A-25). This aluminum skiff, made by Pacific Boats, has a draft of 2 feet and a beam of 8.5 feet. The vessel is propelled by a 225-horsepower Honda outboard engine and has a 9.9-horsepower Honda kicker motor.

Credit: NWFSC

Figure A-26. R/V *Minnow*

The R/V *Minnow* is a 21-foot NMFS vessel made by Workskiff (Figure A-26). The vessel has a 2.5-foot draft, an 8-foot beam, an aluminum hull, and a T-top center console. It is propelled by a 135-horsepower Honda outboard engine and has an 8-horsepower Honda kicker motor.

Figure A-27. R/V *Tule*

The R/V *Tule* is a 19-foot Magnum-brand aluminum skiff with a 90-horsepower Honda outboard engine (Figure A-27). It has a center console and a hefty towing post in the back for pulling in a purse seine. The skiff accompanies the purse seiner R/V *Pelican*. Both vessels are used exclusively for studying salmon habitat-use in the Lower Columbia River estuary.

Credit: David Fox, Oregon Department of Fish & Wildlife

Figure A-28. R/V *Elakha*

The R/V *Elakha* is a 54-foot, aluminum-hulled vessel owned by Oregon State University (Figure A-28). The vessel was built by Rozema Boat Works in Mount Vernon, WA and is propelled by a Caterpillar 3176B 6-cylinder diesel engine, capable of up to 600 horsepower. The R/V *Elakha* is home ported in Newport, OR and has a draft of 5 feet and a beam of 16.5 feet. It is outfitted with an A-frame, a winch, a transducer well, and other scientific equipment.

Figure A-29. M/V *Forerunner*

The M/V *Forerunner* is a 50-foot, steel-hulled vessel owned by Clatsop Community College (CCC) in Astoria, Oregon (Figure A-29). Originally launched as a commercial fishing vessel in 1969, CCC acquired M/V *Forerunner* in 1974. The vessel underwent a major overhaul in 2010. M/V *Forerunner* has a draft of 6.5 feet and is propelled by a 335-horsepower engine (CCC 2013).

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